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Refinery Process Heater NOx Reductions Using Staged Combustion Air Lances

KVB, Inc.
Irvine, CA

Prepared for

Industrial Environmental Research Lab.
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REFINERY PROCESS HEATER NO_x REDUCTIONS USING STAGED COMBUSTION AIR LANCES

by

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The report gives results of full scale tests to evaluate combustion modifications for emission control and efficiency enhancement on petroleum process heaters. Test objectives were to determine NOx emission reductions, thermal efficiency changes, long-term performance, and cost of a staged combustion air modification (the most promising combustion modification in pilot scale tests). The test unit was a vertical, cylindrical, natural-draft crude-oil heater; test fuels were natural gas, refinery gas, and a combination of No. 6 oil and refinery gas. The unit had a 16 MW heat input capacity and was capable of a throughput of 108 cu m/h of crude oil. Firing refinery gas at normal excess air levels (4% stack O2) at 10.4 MW heat input during a long-term test, the staged air modification lowered NOx emissions by 60% below a baseline of 66 ng/J while increasing thermal efficiency slightly. At 2% stack O2, the NOx reduction reached 71% and heater thermal efficiency was increased by about 3% of the baseline thermal efficiency. For the combined refinery gas/No. 6 oil fuel at normal excess air and the same heat input rate, the NOx reduction with the application of staged air was 34% below a baseline of 115 ng/J. At 2% stack O2, this improved to 53%. Thermal efficiency increases at these conditions were nominally the same as observed for the refinery gas fuel.

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ABSTRACT

Results of full scale tests to evaluate combustion modifications for emission reduction and efficiency enhancement on petroleum process heaters are reported. The objectives were to determine NO_x emission reductions, thermal efficiency changes, long-term performance, and cost of a staged combustion air modification, which had been shown to be the most promising combustion modification in pilot scale tests. The test unit was a vertical cylindrical natural draft crude heater and the test fuels were natural gas, refinery gas, and a combination of No. 6 oil and refinery gas. The unit had a 16 MW heat input capacity and was capable of a throughput of 108 m^3/h of crude oil. Firing refinery gas at normal excess air levels (4% stack O_2) at 10.4 MW heat input during a long-term test, the staged air modification lowered NO_x emissions by 60 percent below a baseline of 66 ng/J while increasing thermal efficiency slightly. At 2% stack O_2 the NO_x reduction reached 71 percent and heater thermal efficiency was increased by about 3 percent of the baseline thermal efficiency. For the combined refinery gas/No. 6 oil fuel at normal excess air and the same heat input rate, the NO_x reduction with the application of staged air was 34 percent below a baseline of 115 ng/J. At 2% stack O_2 this improved to 53 percent. Thermal efficiency increases at these conditions were nominally the same as observed for the refinery gas fuel. Long-term (30-day) evaluation of the staged air system revealed no special operating difficulties or process constraints and the system appeared to suffer no significant degradation. The cost of the modification was determined based on a permanent system.

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Limitations on Application of Data Reported

The pollutant emission data cited in this report pertain to one specific classification of refinery process heaters, i.e., vertical cylindrical natural draft crude heaters. These data should not be used to estimate mean emissions from other types of heaters or to predict emission reduction potentials of combustion modifications until the modifications have actually been carried out on the different heater types.

SECTION 1.0

INTRODUCTION AND SUMMARY

This final report is one of a series of four final reports which cover the pilot scale and full scale tests of advanced combustion modification technology for reduction of NO_x emissions and the enhancement of thermal efficiency on industrial process equipment. This work was performed under EPA Contract No. 68-02-2645 over the period from August 1977 to June 1981.

The activities summarized herein include field evaluations of several modification techniques applied to a natural draft crude oil heater. Test efforts focused on a new method of staged combustion which can be retrofitted on a wide variety of process heaters and can achieve NO_x reductions of over 50 percent from baseline along with modest efficiency increases.

The modifications discussed in this report had previously been applied to a pilot scale natural draft heater as a part of this program in a series of tests aimed at determining the most promising techniques for full scale application. Emphasis was placed on assessing modifications which required relatively minor hardware changes which could be made easily on a wide range of existing process heater types.

Prior to the present program, testing of full scale process heaters was conducted on EPA Contract No. 68-02-2144 in which operating variables such as excess air and load were adjusted in order to lower NO_x emissions. No hardware changes to the units were made during those tests, however.

1.1 OBJECTIVES AND SCOPE

The objective of this program was to investigate advanced combustion modification concepts requiring relatively minor hardware modifications that could be used by operators and/or manufacturers of selected industrial process equipment to reduce emissions and to improve thermal efficiency. The development was to be performed for equipment in which the modifications would be most widely applicable and of the most significance in mitigating the impact of stationary source emissions on the environment. Another objective was to assess the feasibility of these modifications to the extent that they could be readily adopted by the fuel burning equipment manufacturers. The path to this goal included concept definitions, economic and technical assessment, subscale performance evaluation tests, cost/benefit analysis, full scale equipment modification or retrofit, full scale performance evaluation tests, and preparation of final reports and instructional guidelines.

1.2 PAST WORK

The present program is a follow-on study intended to build upon the results of the program reported in EPA-600/7-79-015a (Ref. 1). The objective of that earlier effort was to investigate the effectiveness and applicability of combustion modifications involving only operating variable changes as means of improvement in thermal efficiency and for emissions control in industrial and combustion equipment. In that project (EPA Contract No. 68-02-2144), a survey of various kinds of industrial equipment for energy consumption and emissions was conducted. Existing data were collected, and equipment manufacturers, operators, and associations were contacted. Industries were defined for which emissions reduction or efficiency increase through combustion improvement would be of significance on a national basis. These industries were petroleum refining, minerals, paper, and metals. The characteristics of specific combustion equipment of most importance in those industries were defined within the limitations of available data. These characteristics were used as guides in selection of test units that would be most nearly representative of the total population.

The program scope provided for tests on 22 industrial combustion devices representative of kilns, process furnaces, boilers, stationary engines, and gas turbines in industrial use. Emissions measured included NO, NO_2, SO_2, SO_3, CO, CO_2, O_2, gaseous hydrocarbons, and where possible, particulates, particle size distribution, smoke number, and opacity. Combustion modifications evaluated, where possible, included lowered excess air, staged combustion, reduced air preheat, and burner register adjustments. No hardware modifications were attempted, however. All experiments involved only operating changes.

The device types that were tested and a brief summary of NO_x emissions, reductions, and control methods are shown in Table 1-1. In general, the results indicate that combustion modifications could be applied to industrial combustion equipment, but reductions achievable varied significantly for different types of devices. Reductions in NO_x of up to 69 percent were observed, but on many devices, reductions were less than 10 percent.

As a part of the present combustion modification program (EPA Contract No. 68-02-2645) tests on a pilot scale natural draft process heater firing natural gas, No. 2 oil, No. 6 oil, and shale oil were made. These tests were the subject of a final report for EPA Contract No. 68-02-2645 (Ref. 2).

Several combustion modifications, most of which involved minor hardware changes, were evaluated during these tests. They included the following:

- Low-NO_x burners
- Staged combustion air through floor lances
- Staged combustion air through a central cylinder
- Steam injection
- Flue gas recirculation
- Altered fuel injection geometry
- Lowered excess air

The results of the pilot scale tests are summarized below:

1. For a subscale natural draft process heater, baseline NO_x levels for two standard burners (John Zink MA-16 and DBA-16) ranged from 54.6 to 67.0 ng/J firing natural gas. One standard burner was found to emit 150 ng/J firing No. 6 oil and 63 ng/J firing No. 2 oil. The range of baseline emissions resulted from variations in stack gas temperatures. (Because of a long heat-up time and the necessity of idling the unit each night, it was virtually impossible to maintain steady state stack gas temperatures.)

TABLE 1-1. INDUSTRIAL COMBUSTION TEST UNITS SELECTED AND SUMMARY OF RESULTS OBTAINED UNDER EPA CONTRACT 68-02-2144

Device Type	Test Site No.	Rated Heat Input, MW	Fuel	Average Baseline NO_x		Maximum Percent Reduction in NO_x	Combustion Modification[b]
				ng/J[a]	ppm at 3% O_2		
Natural Draft Process Heater	4	25.0	Ref. Gas	59	116	18	4 of 32 BOOS
Natural Draft Process Heater	5/1	15.9	Ref. Gas	50	97	22	Air Register Adjust
Natural Draft Process Heater	5/2	10.1	Ref. Gas	39	76	21	High Load, Low O_2
Natural Draft Process Heater	7/1	15.5	Ref. Gas	52	103	8	2 of 16 BOOS
Natural Draft Process Heater	7/2	11.0	Ref. Gas	49	98	27	Air Register Adjust
Forced Draft Heater, Air Preheat	12/1	27.5	Ref. Gas	163	320	0	Baseline is Lowest NO_x
	12/1		No. 6 Oil	113	222	0	Baseline is Lowest NO_x
Forced Draft Heater, No Air Preheat	12/2	13.6	Ref. Gas	109	214	67	Low O_2
	12/2		No. 6 Oil	97	172	15	Low O_2
Clay Tunnel Kiln	1	9.4	Nat. Gas	46	90	41	Low O_2
Rotary Cement Kiln (Dry Process)	3	70.3	Nat. Gas NG + Coke	903	1460	27	Fuel Switch, Gas to Coke
Rotary Cement Kiln (Wet Process)	9	59.0	Nat. Gas	1319	2250	14	Low O_2, High Air Temperature
Steel Open Hearth Furnace	14	57.0	NG + No. 6 Oil	1094	2070 (Avg)	40	Low O_2
Steel Reheat Furnace	16/1	35.0	Nat. Gas	56	110	43	3 of 27 BOOS
Steel Soaking Pit	16/2	2.9	Nat. Gas	52	101	69	Low O_2
Aluminum Melter	6	10.6	Nat. Gas	49	96	0	Low O_2 (NO_x Increased)
	6		No. 2 Oil	104	185	0	Low O_2 (NO_x Increased)
Wood Bark Boiler	13	34.0	Wood+Coal	188	300	15	Low O_2
Wood Bark Boiler	10/1	69.0	Wood+NG	124	229	23	1 of 4 BOOS
Black Liquor Recovery Boiler	10/2	117.0	Liquor	35	52	30	Secondary Air Adjust
CO Boiler	11	135.0	CO Gas	147	126	12	Air Register Adjust
Natural Gas Engine	2	3.2	Nat. Gas	1020	1990	20	Fuel, Air Adjust
Diesel Engine	15	1.8	No. 2 Oil	904	1611	19	Low Inlet Air Temperature
Gas Turbine Combined Cycle	7/3	230.0	Ref. Gas	59	118	14	1 of 8 BOOS
Gas Turbine Combined Cycle	8	728.0	Ref. Gas	52	103	38	4 of 16 BOOS

[a] 1 lb/10^6 Btu = 430 ng/J

[b] BOOS = Burners Out of Service

2. Two low-NO_x burner designs (a tertiary air and a recirculating tile design) had baseline* NO_x emissions ranging from 47.1 to 53.0 ng/J firing *natural gas*. Thus, the mean NO_x emission level from these burners was about 18 percent lower than the mean value for the two standard burners. Firing *No. 6 oil*, one low-NO_x burner design produced 149 ng/J, a reduction of 7 percent below the standard burner. The reduction of NO_x due to the low-NO_x burner when firing *No. 2 oil* was only 2 percent below the standard burner baseline.

3. Combustion modification techniques were effective in reducing NO_x emissions on a subscale process heater firing either *natural gas* or *No. 6 oil*. Staged combustion air accomplished by lances through the heater floor and coupled with lowered excess air was the most effective technique, followed by flue gas recirculation at either normal or reduced excess air. When properly adjusted and under reduced excess air conditions, a low-NO_x (tertiary air design) burner was also shown to be effective in lowering NO_x emissions firing both *natural gas* and *No. 6 fuel oil*. Lowered excess air alone without other modifications was not very effective in reducing the NO_x concentration when firing *No. 6 oil*.

4. Modifications which worked well firing gas fuel but which were not tried firing oil because of time or test equipment limitations included staged combustion air using a central cylinder above the primary air zone, steam injection, and altered fuel injection geometry. Each of these modifications reduced NO_x emissions by more than 30 percent below baseline and some may be applicable to oil firing as well as gas firing.

5. Staged combustion air by means of floor lances reduced the NO_x at a normal operating excess air level by 46 percent below baseline (54.6 ng/J) firing *natural gas* fuel. At lowered O_2 levels with staged air, the reduction was as much as 67 percent (*natural gas* fuel). At normal O_2 conditions the NO_x reduction firing *No. 6 oil* was 35 percent below baseline (160 ng/J) and at reduced O_2, the reduction reached 51 percent. This staged air technique was also the most cost-effective technique based on the data available. Costs were predicted to be roughly $700/Mg of NO_x reduction for

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*Baseline conditions were defined for both standard and low-NO_x burners firing as 3% stack O_2, 1.5 MW thermal input, all registers 100 percent open, and stack gas temperatures of 1100-1200K. Values are nominal.

small heaters (2.9 MW and below) firing gas dropping to only \$39/Mg of NO_x reduction for large heaters (147 MW and above) firing oil.

6. Cost calculations did not include annual fuel costs or savings due to the combustion modifications because of the unrealistically large efficiency changes that were observed on the small-scale heater.

1.3 PRESENT TEST PROGRAM APPROACH

A detailed summary of test results and a discussion of those results are presented in Sections 3.0, 4.0, and 5.0. A brief review of the program approach is presented here.

Following the work discussed in the previous section, a location was sought which would permit the application of combustion modifications and, in particular, the installation of staged combustion air lances, on a full scale operating process heater. A natural draft vertical cylindrical crude heater containing six John Zink burners, capable of combined fuel firing of the same design as those previously tested at the pilot scale facility was found.

An initial series of tests was conducted to determine heater performance over a range of operating variables such as excess air, load, and air register settings for various fuel types. The tests were similar to the previous full scale tests mentioned earlier in that no hardware modifications were made to effect combustion modifications.

Once the performance of the heater was documented over its normal range of operating parameters, staged combustion air was implemented. A prototype system, constructed largely of polyvinyl chloride pipe, fittings, and valves with twenty-four stainless steel lances (four per burner) was built. The system was designed to provide maximum flexibility and flow control for minimum cost. The heater was then reevaluated over the same ranges of operating parameters. During testing of the staged air system several new parameters were varied. These included burner stoichiometric ratios, staged air insertion height, and staged air lance orientation. An optimum low-NO_x operating condition was defined as the configuration at which the lowest NO_x concentrations were obtained while still permitting stable heater operation without a significant increase in CO emissions. This condition was defined for gaseous fuel and for a 50/50 mixture of No. 6 oil and gas.

A 30-day test was then conducted with the staged air system in continuous operation firing refinery gas at the optimum low-NO_x condition. System performance and durability were evaluated as well as the ability to maintain steady heater operation at the low-NO_x condition. At the completion of the long-term test a permanent system was designed. This sytem was intended to be suitable for a typical furnace of the same type as that tested on this program.

The cost, based on the permanent system design, of the staged combustion modification was evaluated for the gaseous fuel and for the combination fuel, and also at two levels of stack oxygen.

A summary of the significant results obtained during the full scale test program is given in Table 1-2.

1.4 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be drawn from the field testing and analyses performed on this project.

- Lowered excess air and staged combustion air reduced NO_x emissions on a natural draft vertical cylindrical process heater firing either gas only or No. 6 oil and gas.
- Steam injection was not effective in reducing NO_x emission firing refinery gas.
- In a long-term test, the combination of staged combustion air and lowered excess air reduced NO_x emissions by 71 percent below a baseline of 66 ng/J (as determined by spot measurements prior to and at the completion of the 30-day test) firing refinery gas while decreasing fuel consumption by nearly five percent.
- Some form of automatic stack O_2 control is necessary in order to maintain the desired low stack oxygen content which produced optimum low NO_x operation.

TABLE 1-2. SUMMARY OF RESULTS OF COMBUSTION MODIFICATION TESTS ON A FULL-SCALE PROCESS HEATER

Heat Input MW	Fuel Type	Baseline NO_x ng/J	Baseline NO_x ppm dry at 3% O_2	NO_x Reduc. From Baseline %	Change in Fuel Cons. %	Combustion Modification
10.4	Ref. gas	66	125	60	-0.2	SCA(1)
10.4	Ref. gas	66	125	71	-4.8	SCA + LEA(2)
9.0	Ref. gas	54	105	15	-2.8	LEA
13.7	Ref. gas	61	120	2.5	+2.2	Steam inj.
13.2	No. 6 oil + Ref. Gas	114	212	34	-0.6	SCA
13.1	No. 6 Oil + Ref. Gas	115	214	53	-4.8	SCA + LEA
13.1	No. 6 Oil + Ref. Gas	115	214	28	-3.0	LEA

(1)SCA = Staged Combustion Air

(2)LEA = Lowered Excess Air

- Without an automatic O_2 trim system, the staged air system operated at normal overall excess air levels when firing refinery gas in a long-term test reduced NO_x emissions by 60 percent below the 66 ng/J value. Fuel consumption decreased by about 0.2 percent.

- The staged combustion air system can function effectively and continuously with little operator attention and little lance deterioration over a 30-day period.

- The NO_x reduction obtained by lowering the excess air without staged combustion was 15 percent below baseline firing refinery gas and 35 percent below baseline firing a 50-50 mixture (by heat input) of refinery gas and No. 6 oil. Accompanying reductions in fuel consumption were 2.8 percent firing refinery gas and 3.0 percent firing both fuels.

- The staged combustion air system is expected to be applicable to most types of refinery heaters, whether forced draft or natural draft and whether vertical or horizontal. The cost effectiveness is likely to be site specific, however.

- Pilot scale predictions for NO_x reductions on a natural draft process heater with staged combustion air are expected to be valid for 100 percent No. 6 oil firing in a full scale heater.

- The cost of staged combustion air on a natural draft process heater applied at normal stack O_2 is calculated as $2636/Mg NO_x reduction for a 16.1 MW heater and decreases to $1934/Mg at 147 MW heat input.

- The cost of staged combustion air combined with lowered excess air on a natural draft process heater applied at 2 percent stack O_2 is calculated as $1089/Mg for a 16.1 MW unit. The cost becomes negative for a 147 MW unit indicating a savings associated with the combined modifications. This cost includes the purchase of an automatic stack draft controller to allow operation of the heater at lowered O_2.

The following recommendations are made for future test work involving combustion modifications for NO_x control on process heaters:

1. The technique of staged air should be evaluated for a naturally drafted air injection system in order to eliminate the cost of installing and operating a blower.

2. The use of slower air velocities in a staged air system would reduce the pressure requirements of the blower, thereby lowering costs. Larger diameter air lances could perhaps be combined with a lower pressure blower than that used in the present tests.

3. The staged air system should be coupled with some type of automatic stack O_2 control system in order to achieve optimum heater performance with respect to NO_x and CO emission levels as well as heater thermal efficiency.

4. The staged air system should be tested firing 100 percent No. 6 oil fuel.

5. The staged combustion lances should be applied to forced draft units both with and without air preheat in order to assess NO_x reduction potentials and cost effectiveness. Presumably, a special staged air blower would not be required on such units, thus reducing costs (although interfacing with an existing air supply system--particularly for preheated units--might be more costly than modifying a relatively simple natural draft heater).

SECTION 2.0

TEST EQUIPMENT DESCRIPTION

2.1 EMISSIONS SAMPLING EQUIPMENT

Gaseous emission measurements were made using analytical instruments and equipment contained in a government-furnished mobile instrumentation laboratory. A plan view of the trailer is shown in Appendix A. Total particulate measurements were made using an EPA Method 5 sampling train manufactured by Andersen Samplers, Inc. Particulate size distribution was measured using an Andersen Mark III Cascade Impactor. Total oxides of sulfur were measured by wet chemistry methods using the sampling train and analytical procedure of the Goksoyr-Ross method. Smoke density was measured using an automated Bacharach smoke spot pump. Stack opacity readings were made during particulate tests according to EPA Method 9.

2.1.1 Gaseous Emissions Sampling System

The laboratory is equipped with analytical instruments to continuously measure concentrations of NO, NO_2, CO, CO_2, O_2, SO_2, and hydrocarbons. The sample gas is delivered to the analyzers at the proper condition and flow rate through the sampling and conditioning system described below. Appendix A describes the analytical instrumentation and the details of the sampling system. Also, a flow schematic and description of the flue gas sampling and analyzing system is presented in detail in Appendix A. Briefly, the sampling system used pumps to continuously draw flue gas from the heater into the laboratory. A high-capacity heated positive displacement diaphragm pump was used to draw a high volume of flue gas into the analyzers thereby providing adequate system response.

Special precautions were required to obtain a representative sample for the analysis of NO_2, SO_2, and hydrocarbons. These precautions consisted primarily of insuring that the sample was kept above its dew point, since these constituents are quite soluble in water. For this reason, an electrically heated 9.5 mm (3/8 in.) Teflon sample line was used to bring the sample into the laboratory for analysis. The hot pump provided heated sample directly to the hydrocarbon, SO_2, and NO_x analyzers.

A portion of the sample pump discharge was also sent through a refrigerated condenser [to reduce the dew point to 275 K (35°F)], through a large rotameter with flow control valve, and then to the O_2, NO, CO, and CO_2 instrumentation. Flow to each individual analyzer was measured and controlled with smaller rotameters and flow control valves. Excess sample was vented outside the laboratory.

2.1.2 Particulate Emissions

Particulate samples were taken at the same sample location as the gas sample using an Andersen Samplers, Inc. portable effluent sampler. These tests were made at baseline and optimum low-NO_x operating conditions. This system, which meets EPA design specifications for Test Method 5, Determination of Particulate Emissions from Stationary Sources (Federal Register, Volume 36, No. 27, page 24888, December 23, 1971) was used to perform both the initial velocity traverse and the particulate sample collection. Dry particulates were collected in a heated case that contained a 110 mm glass-fiber filter for retention of particles down to 0.3 micrometers. Condensible particulates are collected in a train of four impingers in a chilled water bath.

Particle size was measured at baseline and optimum low-NO_x conditions at the same sample location as the Method 5 tests. An Andersen Mark III Cascade Impactor was used for all of the sizing tests because of its high-volume/low grain loading capability. This impactor was capable of fractionating particles in situ into nine aerodynamic size ranges (eight collection stages and one backup filter). The size range capability of this impactor was approximately 0.4 μm to 10 μm.

The Method 5 sampling train and procedures, and the impactor operational procedures, are discussed in Appendix A.

2.1.3 Wet Chemical SO_x Measurement

The Goksoyr-Ross technique was used to sample the stack gas for SO_3. This method uses controlled condensation of the stack gases in a coil maintained at 333-344 K (140-160°F) by a water bath. This temperature is below the sulfuric acid (H_2SO_4) dewpoint so that the SO_3 and the water vapor in the flue gas condense upon the coil walls to form H_2SO_4 droplets. The SO_2 in the flue gas passes through the coil and is collected in impingers containing a weak hydrogen peroxide solution. Following the impingers, the flue gas flows through a dry gas meter and is then discharged into the atmosphere.

The coil rinse and impinger liquid are each analyzed by means of an acid-base titration with a sodium hydroxide solution. Thus, both the SO_3 and SO_2 concentrations may be determined from this procedure.

2.1.4 Smoke Spot and Opacity Measurement

On combustion equipment where smoke numbers normally are taken, such as oil-fired boilers, KVB, Inc. determines the smoke number using test procedures according to ASTM Designation: D 2156-65. The smoke number is determined at each combustion modification setting of the unit. Examples are baseline, minimum excess air, low load, etc., and whenever a particulate concentration is measured.

Smoke spots are obtained by pulling a fixed volume of flue gas through a fixed area of a standard filter paper. The color (or shade) of the spots that are produced is visually matched with a standard scale. The result is a "Smoke Number" which is used to characterize the density of smoke in the flue gas.

Opacity readings are taken by a field crew member who is a certified graduate of a U.S. Environmental Protection Agency approved "Smoke School." Observations are made at the same time that particulate measurements are made and as often in addition as deemed necessary to gather the maximum amount of information. The procedures set forth in EPA Method 9, "Visual Determinations of the Opacity of Emissions for Stationary Sources," are followed.

2.2 TEST HEATER DESCRIPTION

The test unit was a natural draft, vertical cylindrical crude oil process heater which is used to supply a heated charge to a crude oil distillation column. A maximum load of 108 m^3/h (16,250 bbl/d) could be sent through the heater in two passes. A sketch of this crude oil heater is presented in Figure 2-1.

The maximum firing rate of the heater was 16.1 MW thermal input (55 x 10^6 Btu/hr). It was fired by six John Zink DBA-22* natural draft burners. The burners were combination gas/oil burners rated at a maximum of 2.68 MW (9.14 x 10^6 Btu/hr) each with a turndown ratio of 3:1. Although combination gas/oil burners were used, some gas was always fired because the unit was base loaded on oil fuel and an automatic temperature controller adjusted the gas fuel flow to maintain crude oil outlet temperature. During tests in which both gas and oil were fired simultaneously, each burner fired approximately the same fuel split. Plan and elevation views of the burners used are shown in Figures 2-2a and 2-2b.

Three parameters could be controlled in the heater: excess oxygen (by furnace draft), firing rate, and load. The stack damper was the main control for the pressure drop across the furnace. The pressure drop could also be controlled by opening or closing the secondary air registers on each burner. A sound-suppression chamber installed on the bottom of the heater permitted access to the secondary air registers. The primary air to the burners was controlled by louvers on the bottom of the sound-suppression chamber. The stack damper and register adjustments established the excess oxygen. The load was controlled by pumps and valves on the inlet and outlet of the heater.

This heater was chosen because of its simple design and flexibility of operation. (Temperature profiles in crude heaters are not as critical as in other stages of the refining process.) Further, the unit contained John Zink burners which were nearly identical to those tested in the prior pilot scale program mentioned earlier. This allowed direct application of the experience gained at the pilot scale level.

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*Mention of trade names does not constitute endorsement by the Environmental Protection Agency.

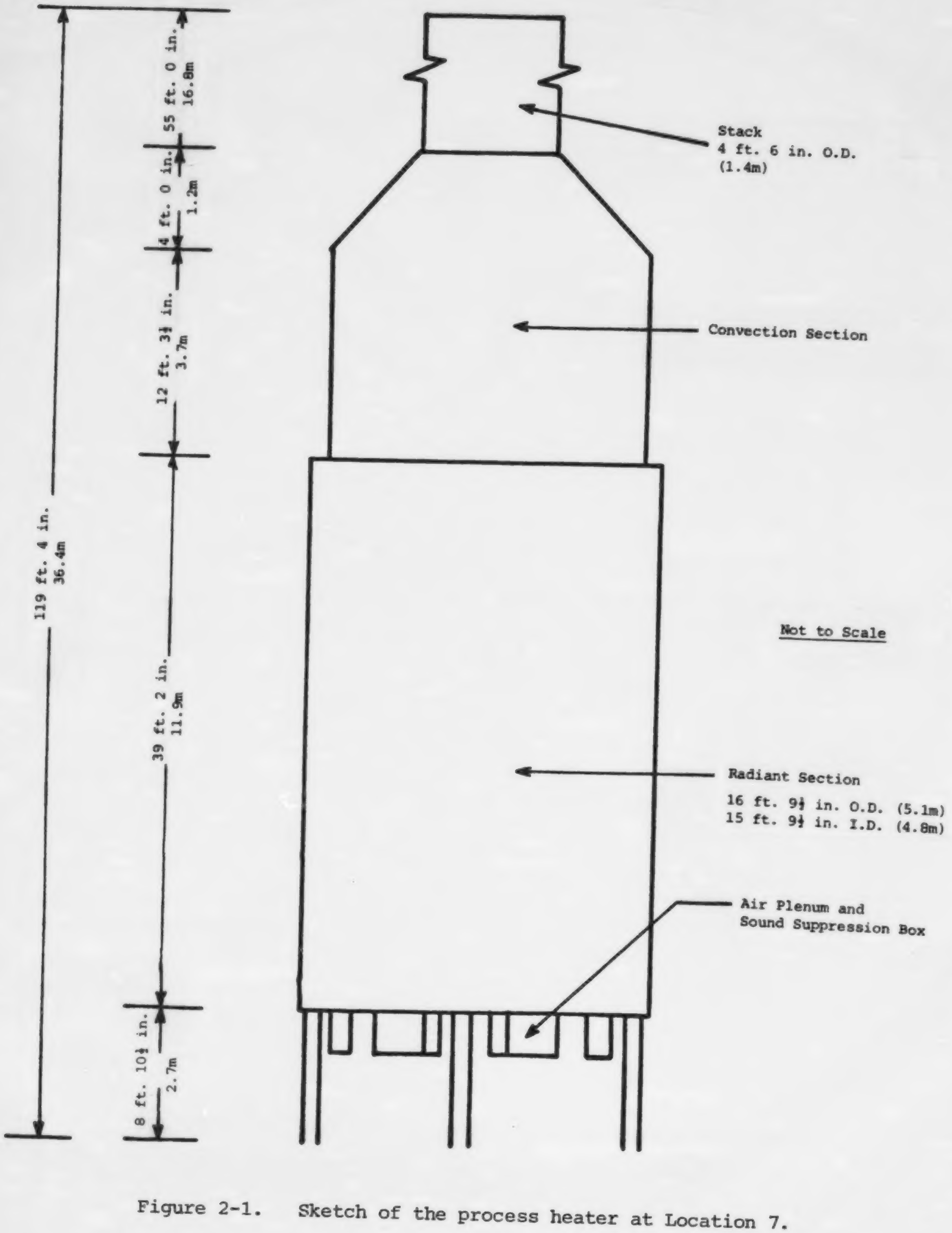

Figure 2-1. Sketch of the process heater at Location 7.

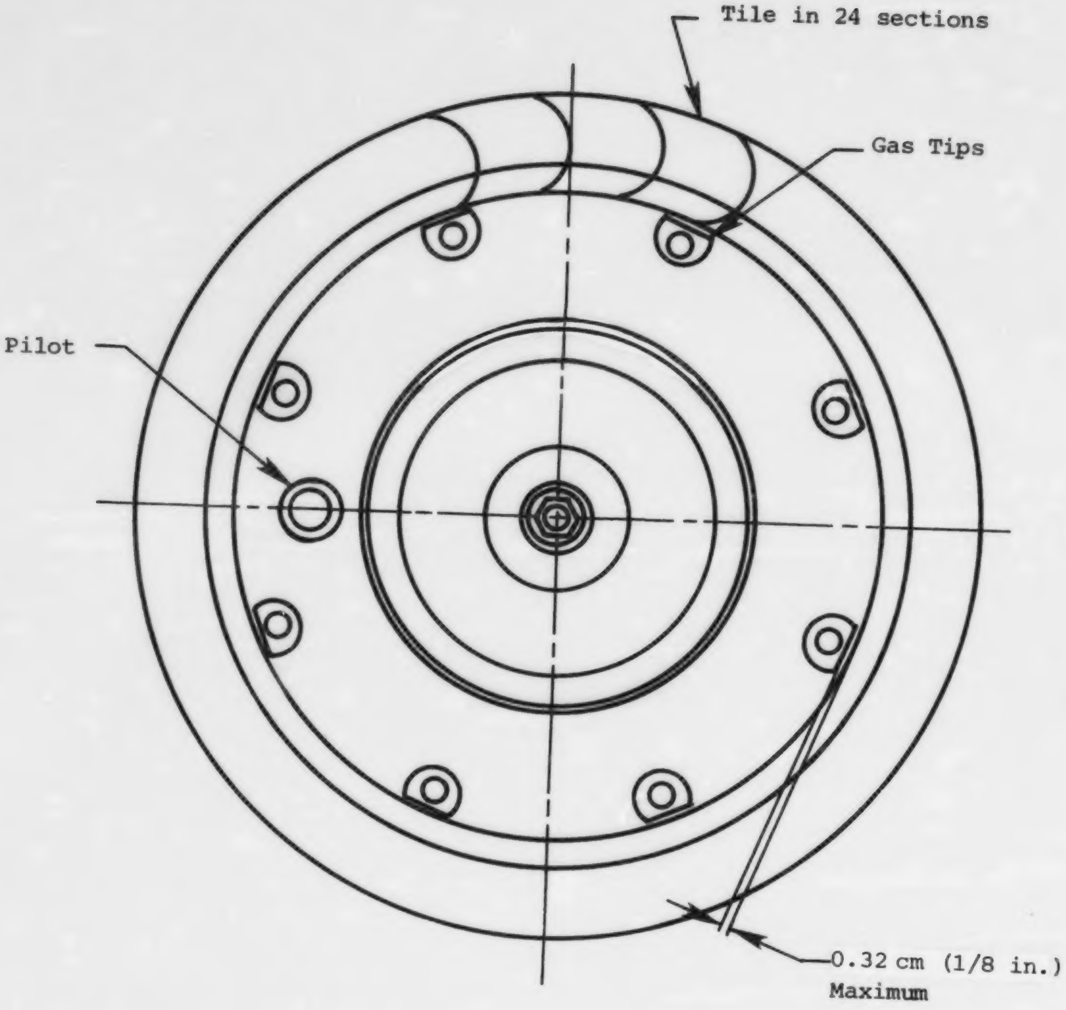

Figure 2-2a. Plan view of DBA-22 combination oil/gas burner used in test heater (courtesy of John Zink Co.)

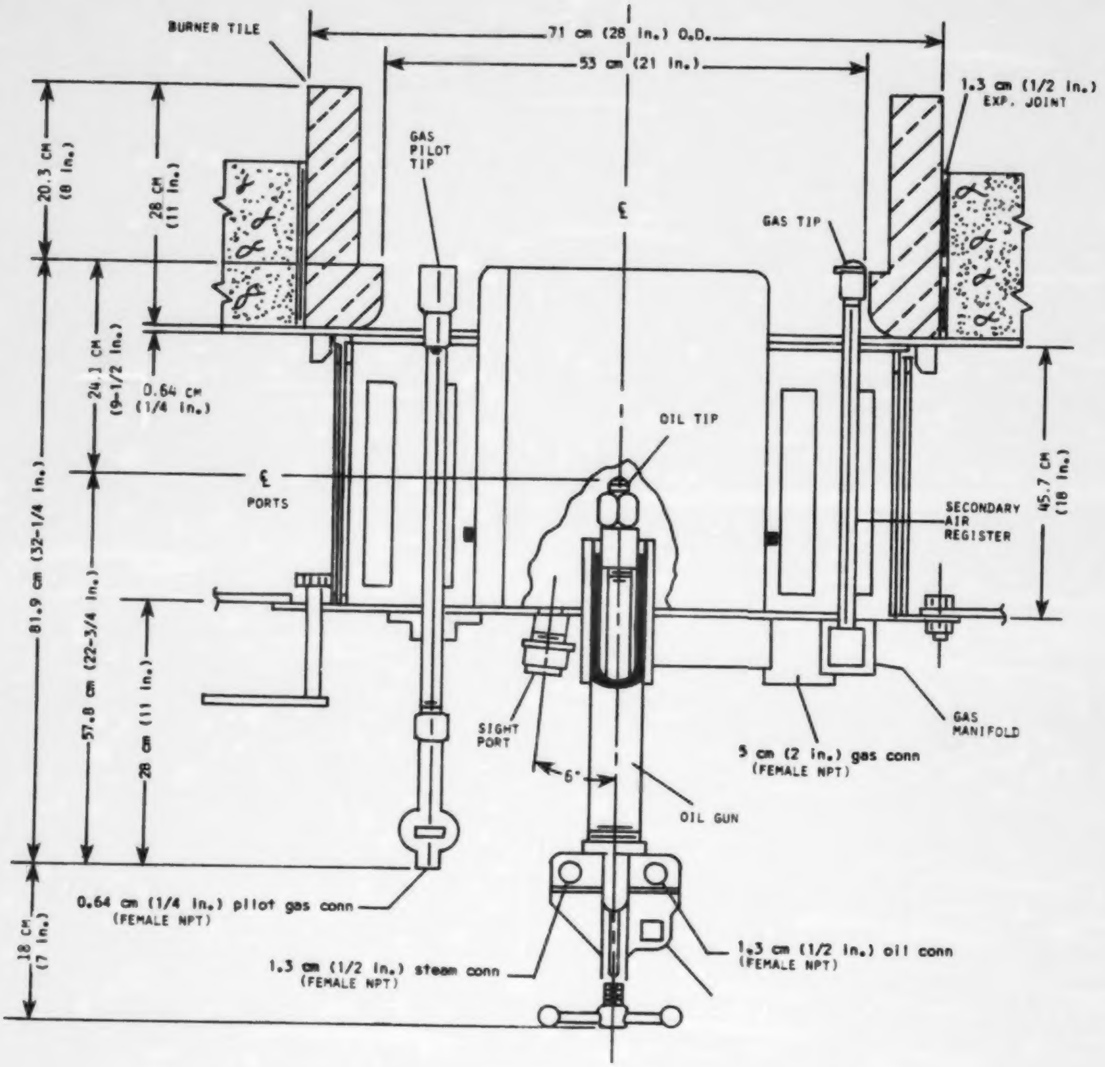

Figure 2-2b. Part sectional elevation of DBA-22 burner (courtesy of John Zink Co.)

2.3 STAGED COMBUSTION AIR SYSTEM

This application of staged combustion utilized air lances in the firebox to supply air to the flame zone a given distance above the base of the flame. Figure 2-3 presents a schematic of this system.

The system consisted of 24 vertical 316L stainless steel pipes 3.18 cm (1-1/4 in.) diameter arranged four-per-burner, 90 deg. apart. A 45-deg. elbow was placed on each pipe to provide better mixing across the flame. A fan supplied air to the lances through a manifold and flexible tubing. The lances could be varied in height up to 1.2 m (four feet) from the floor of the heater. Extensions for the lances allowed staging heights up to 2.4 m (8 ft) for oil firing tests. The lances were placed on a 91.4 cm (36 in.) bolt circle around each of the six burners. The six burners were equally spaced on a 99.1 cm (39 in.) bolt circle around the vertical centerline of the heater.

For the initial tests of staged combustion air firing gaseous fuels and firing refinery gas and No. 6 oil simultaneously, a New York N26P30 blower with a 22 kW (30 hp) motor was used. It produced a maximum of about 1.18 m^3/s (2500 scfm) giving velocities at the staged air injection plane in the furnace of up to roughly 73 m/s (240 ft/sec). The temperature of the staged combustion air at the injection plane and the skin temperature of the lances was measured using thermocouples. The injection air temperature was approximately 422 K (300°F) for maximum staging and the lance skin temperature was generally about 1089 K (1500°F). The staged air flow capability with this blower was approximately 40 percent of the total combustion air at normal heater operating conditions.

A larger staged air blower capable of delivering a maximum air flow of about 1.65 m^3/s (3500 scfm) at velocities of up to about 103 m/s (337 ft/sec) was used for a second set of tests during which improved system performance was obtained for gas/oil fuel mixtures. This represented approximately 50 percent of the total combustion air at normal heater operating conditions. Injection air and lance skin temperatures were measured as being about the same for this blower as they were for the first blower. The blower was a

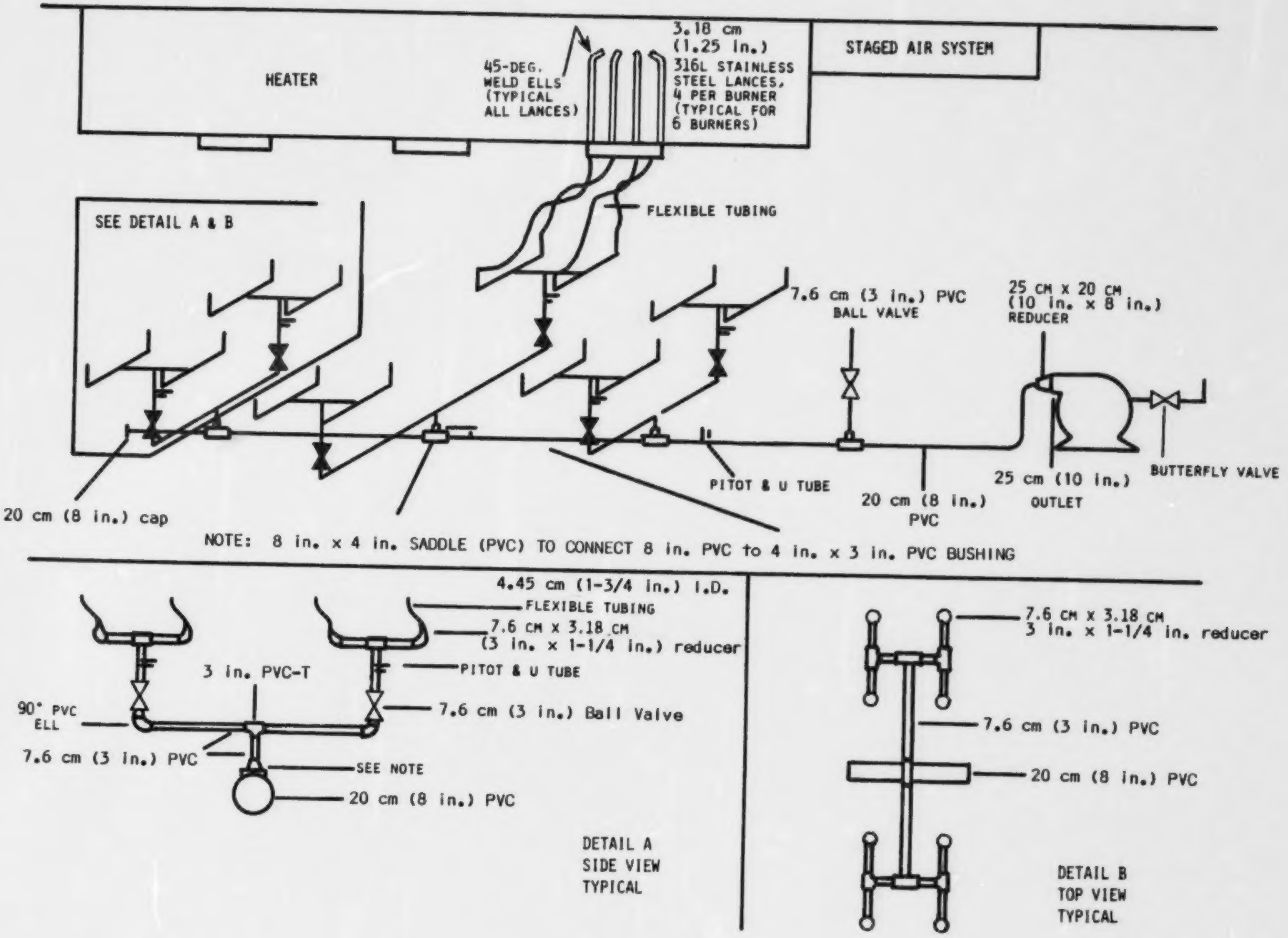
HEATER
45-DEG. WELD ELLS (TYPICAL ALL LANCES)
3.18 cm (1.25 in.) 316L STAINLESS STEEL LANCES, 4 PER BURNER (TYPICAL FOR 6 BURNERS)
STAGED AIR SYSTEM
SEE DETAIL A & B
FLEXIBLE TUBING
7.6 cm (3 in.) PVC BALL VALVE
25 CM x 20 CM (10 in. x 8 in.) REDUCER
BUTTERFLY VALVE
25 cm (10 in.) OUTLET
20 cm (8 in.) PVC
PITOT & U TUBE
20 cm (8 in.) cap
NOTE: 8 in. x 4 in. SADDLE (PVC) TO CONNECT 8 in. PVC to 4 in. x 3 in. PVC BUSHING
4.45 cm (1-3/4 in.) I.D.
FLEXIBLE TUBING
7.6 CM x 3.18 CM (3 in. x 1-1/4 in.) reducer
PITOT & U TUBE
3 in. PVC-T
90° PVC ELL
7.6 cm (3 in.) Ball Valve
7.6 cm (3 in.) PVC
SEE NOTE
20 cm (8 in.) PVC
DETAIL A SIDE VIEW TYPICAL
7.6 CM x 3.18 CM 3 in. x 1-1/4 in. reducer
7.6 cm (3 in.) PVC
20 cm (8 in.) PVC
DETAIL B TOP VIEW TYPICAL

Figure 2-3. Flow schematic of staged combustion air system for a natural draft process heater.

high-pressure ILG Industries Model R33Y type with a 74.6 kW (100 hp) totally enclosed, fan-cooled (TEFC) motor. The TEFC motor was required by refinery standards.

Other than the blower, the stainless steel lances, the flexible hose used to connect the lances to the rest of the system, and the cast iron butterfly valve at the blower intake (used to control the total staged air flow), the entire air delivery system was constructed of polyvinyl chloride (PVC) pipe, fittings, and ball valves. The plant felt that this type of construction would not pose a safety hazard for limited-duration tests. For a permanent installation, however, it is believed that a standard carbon steel piping system would be required.

Total staged combustion air flow was measured by means of a pitot tube in the 25 cm (8 in.) duct at the blower discharge. Flow was also measured to each burner by pitot tubes in the 7.6 cm (3 in.) risers just upstream of the split to the four lances. The flow of air to each burner could be controlled by means of ball valves as shown in Figure 2-3.

2.4 METHOD OF STEAM INJECTION

For several tests when firing gas fuel only, steam was injected through the oil guns in an effort to determine its effects on NO_x levels. Since the oil guns in the burners used steam to atomize the heavy oil which is sometimes fired in the heater, a ready supply of steam was available. Steam pressure at the supply line to each burner was controlled. The flow rate of the steam was calculated from this pressure (relative to the furnace pressure which was essentially ambient) and the area of the orifices in the oil tip using Grashof's formula for choked flow of saturated steam through an orifice. This was necessary since the plant was not equipped to measure the steam flow directly.

The steam flow was increased to as much as 50 percent of the fuel mass flow while the NO_x emissions were monitored.

Steam injection when firing oil fuel (other than the atomizing steam) was not attempted because of the complexity of the modifications required to introduce steam through a source other than the oil guns.

SECTION 3.0

RESULTS OF COMBUSTION MODIFICATION TESTS

3.1 UNMODIFIED HEATER PERFORMANCE

Prior to making any combustion modifications, the refinery heater was thoroughly tested for emissions and efficiency over the normal operating load range. Baseline tests firing gaseous fuel, which usually consisted of a scrubbed refinery off gas from an adsorber and sometimes consisted of a non-scrubbed refinery gas (termed "fuel gas") mixed with natural gas, and tests firing a mixture of the adsorber gas and No. 6 oil were conducted. At each load condition for each fuel a range of excess air levels was tested.

For the gaseous fuel (adsorber gas) baseline NO_x emissions were 54.0 ng/J and the efficiency of the unit was 73.6 percent based on the abbreviated ASME heat loss method. Baseline conditions for this fuel were 63.6 m^3/h (9600 bbl/d) crude oil feed rate and 4 percent O_2 in the stack gas.

For the adsorber gas/No. 6 oil mixture baseline NO_x levels of 115 ng/J were measured along with an ASME efficiency of 76.0 percent. The crude feed rate for these tests was somewhat higher due to a normal change in plant production level. A feed rate of about 75.0 m^3/h (11,300 bbl/d) along with 4 percent O_2 in the stack gas defined baseline conditions firing the mixed gas/oil fuel. The fuel split for most of the combined fuel tests was nominally 50-50 by heat input. The secondary air registers were 33 percent open during baseline conditions during combined fuel firing. Opening the registers to 100 percent open increased emissions to about 131 ng/J.

A complete data summary for the process heater tests is given in Appendix B. Analyses of the various fuels fired are presented in Appendix E.

3.1.1 Load and Excess Air Variations

A series of tests was conducted to evaluate the performance of the process heater with regard to NO_x emission and efficiency over varying load and excess oxygen conditions. These tests were first made while firing a gaseous fuel mixture consisting of natural gas and refinery fuel gas and then while firing residual oil simultaneously with the gas mixture.

The NO emissions as a function of oxygen are shown in Figures 3-1 and 3-2. The highest NO emission generally occurred at the intermediate load condition, ~70% of rated capacity. NO_x emission increased with increasing oxygen up to approximately 4-6 percent O_2 for all fuel combinations. In the 4-6 percent O_2 range, NO emission was relatively insensitive to O_2 level and, at higher O_2, NO emissions decreased.

The nitrogen content of the gaseous fuels was negligible whereas the nitrogen content of the oil fuel was 0.8 percent by weight, hence, the difference in absolute NO emission between Figures 3-1 and 3-2. Several ratios of oil/gas are reported in Figure 3-2. These ratios indicate the approximate fuel split by percentage of total heat input. Changes in the fuel split occurred because (a) gas fuel composition and heating value could change in a short time period and (b) total heat input required to maintain the load could change due to changes in the composition of the crude charge to the heater; as total heat input demand changed, the difference was made up by altering the gas fuel flow rate.

At the intermediate load, the baseline excess oxygen was 4 percent which was regarded by the plant as a normal operating level. The excess oxygen variation tests indicated that continuous operation of the heater at 2 percent O_2 was possible for short-term tests without additional operator supervision. Below this level the heater draft tended to become unstable. Fluctuations in the draft caused occasional smoking of the unit and resulted in positive stack or convection section pressures which are dangerous in a natural draft heater because they can cause flashback. Flashback occurs when a flame encounters a back pressure which forces it downward and out the bottom of the heater through the air registers. (Subsequently, during long-term testing of the staged combustion air modification, it was found that an O_2 control system would be necessary for prolonged operation of the heater at 2 percent O_2.)

3.2 STAGED COMBUSTION AIR TESTING

The next phase of testing at the process heater site involved the evaluation of the staged combustion air system. This evaluation included the

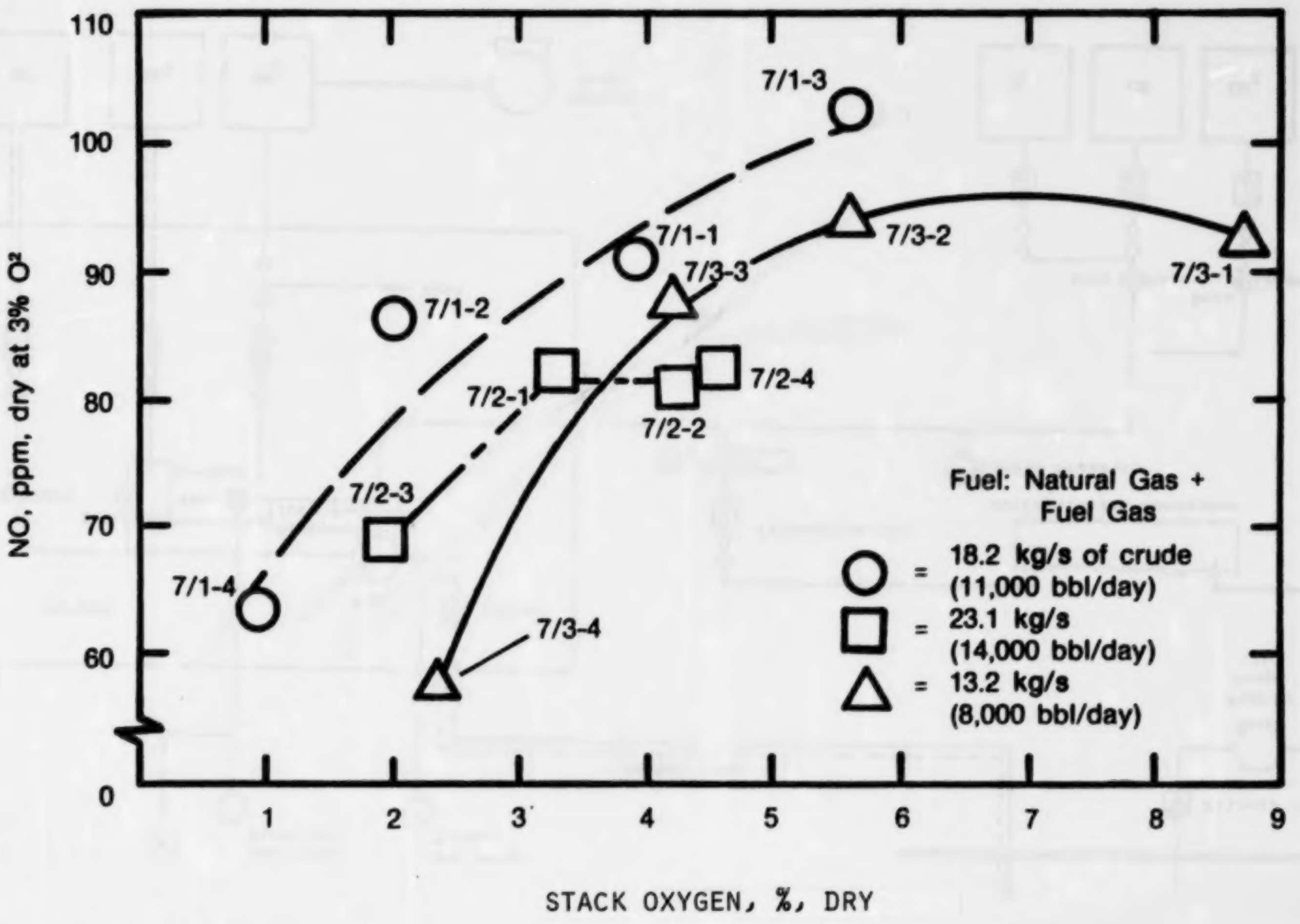

Figure 3-1. NO emissions at three different loads as a function of stack oxygen for a natural draft process heater firing a natural gas/refinery gas mixture.

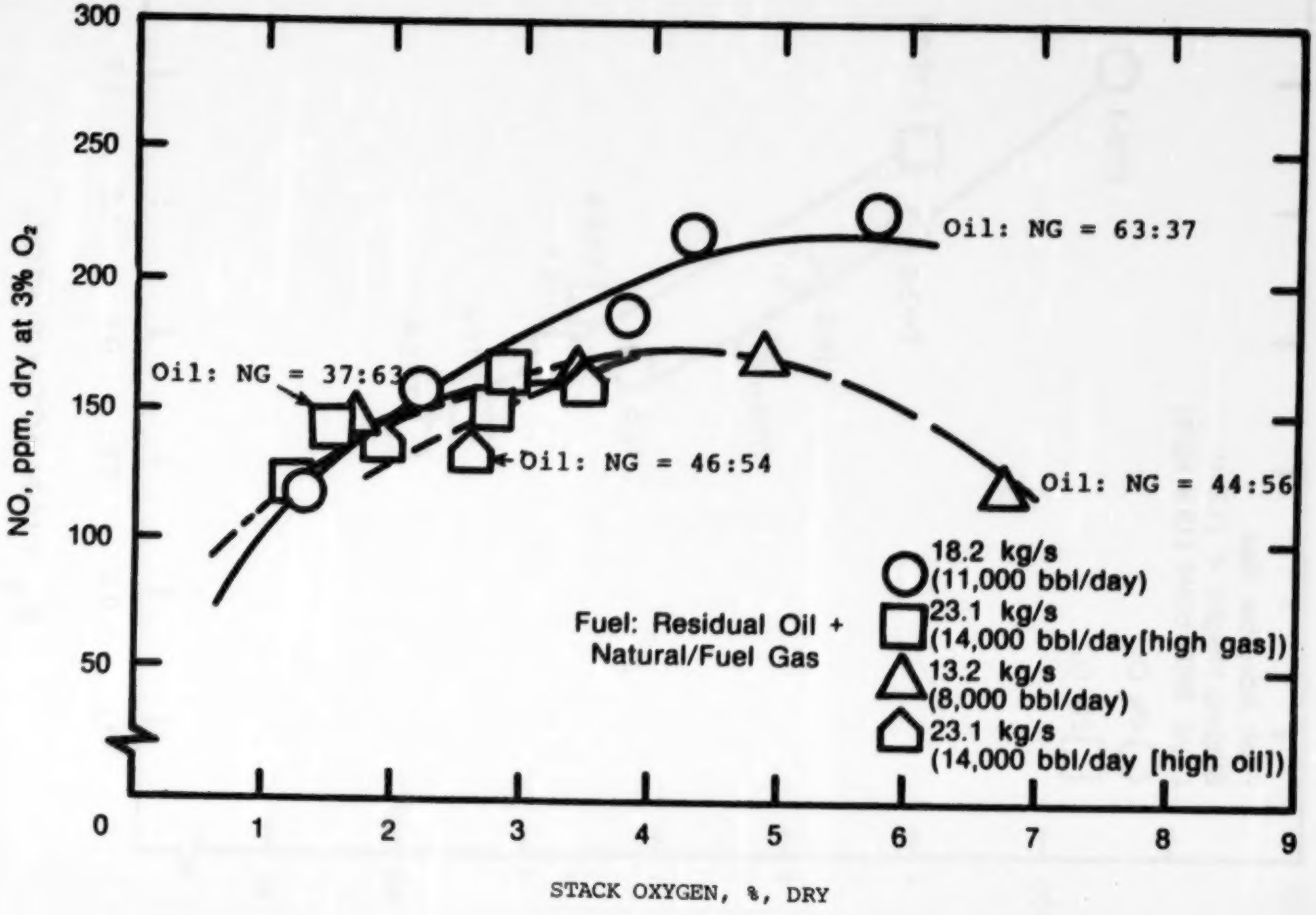

Figure 3-2. NO emissions at three different loads as a function of stack oxygen for a natural draft process heater.

variation of three important parameters: (1) burner equivalence ratio, Φ_B, (2) oxygen level, and (3) staged air insertion height.

For the staged combustion air tests, due to changes in plant operation, it was necessary to fire a different refinery gas from that used in load and oxygen variations. This gas, called "adsorber gas," contained a greater percentage of higher hydrocarbons than did the "fuel gas" or natural gas and, therefore, a higher heating value. Baseline NO emissions with adsorber gas were about 8 percent higher (8 ppm) compared with fuel gas.

The NO emissions are graphed as a function of burner equivalence ratio, $\Phi_B = \frac{(A/F)_{\text{Burner}}}{(A/F)_{\text{Stoichiometric}}}$. The staging height for this test series was 1.2 m (4 ft) and the load was 64 m^3/h (9600 bbl/d), 60 percent of rated capacity. At each overall O_2 level Φ_B was decreased in steps to its minimum value which was determined by the limitations of the staged combustion air fan. Figure 3-3 shows that at 4 percent O_2 the minimum Φ_B (maximum staging) obtained was 0.74 which decreased NO emissions 35 percent below the baseline of 105 ppm, dry at 3 percent O_2. At 2 percent O_2 and minimum Φ_B of 0.65 the NO concentration dropped to 51 ppm, dry, corrected to 3 percent O_2. This represented a reduction of 52 percent below the 4 percent O_2 baseline condition and a 43 percent below the 2 percent O_2 (non-staged) level. Table 3-1 summarizes the NO_x reductions and efficiency changes for the various combustion modifications to the process heater while firing adsorber gas and while firing a combination of adsorber gas and No. 6 oil.* The efficiency increase for the staged air combustion modification combined with lowered excess air was 2.4 percent which would result in a fuel savings of 3.1 percent as is indicated in Table 3-1.

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*The percent change in fuel consumption in Table 3-1 was calculated as follows:

$$\text{\% Change in Fuel Consumption} = \frac{\eta_{\text{Unmod.}} - \eta_{\text{Mod.}}}{\eta_{\text{Mod.}}}$$

Thus, a positive number represents an increase in fuel consumption and a negative number represents a decrease in fuel consumption.

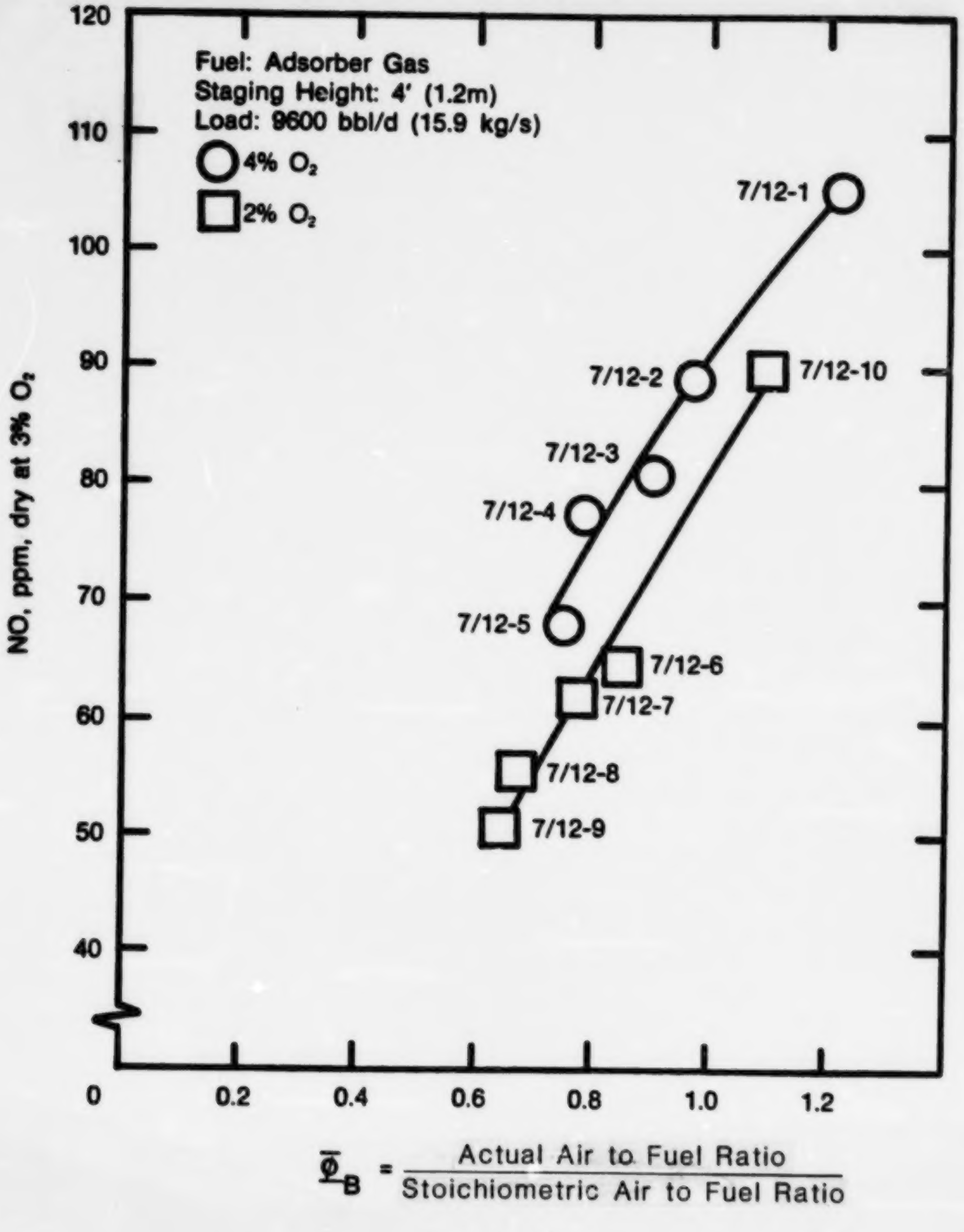

Figure 3-3. NO emissions at 60 percent rated capacity as a function of burner equivalence ratio at two oxygen levels with constant staged air insertion height.

TABLE 3-1. RESULTS OF PARAMETRIC TESTS OF COMBUSTION MODIFICATIONS ON A NATURAL DRAFT PROCESS HEATER

Test No.							
Unmodified	Modified	Modification	NO_x Emissions Unmodified/Modified (ng/J)	% Reduction	Efficiency Unmodified/Modified (%)	% Change in Fuel Consumption	Fuel
5-6	5-7	Steam Injection @ 3% O_2	61.3/59.8	2.5	75.64/74.00	+2.2	Gas
5-4	5-3	Steam Injection @ 2% O_2	57.2/57.2	0	76.64/75.27	+1.8	Gas
7/12-1	7/12-5	SCA @ 4% O_2	54.0/35.0	35.2	73.60/73.73	-0.2	Gas
7/12-10	7/12-9	SCA @ 2% O_2	46.0/26.0	43.5	75.75/75.97	-0.3	Gas
6-11	6-10	SCA @ 4% O_2	114.0/75.1	34.1	78.17/78.62	-0.6	50% No. 6 Oil, 50% Gas
7-2	7-5	SCA @ 2% O_2	83.1/54.2	34.8	78.34/79.88	-1.9	50% No. 6 Oil, 50% Gas
7/12-1	7/12-10	LEA (4% O_2 + 2% O_2)	54.0/46.0	14.8	73.60/75.75	-2.8	Gas
7-1	7-2	LEA (4% O_2 + 2% O_2)	115.0/83.1	27.7	76.01/78.34	-3.0	50% No. 6 Oil, 50% Gas
7/12-1	7/12-9	SCA + LEA	54.0/26.0	51.9	73.60/75.97	-3.1	Gas
7-1	7-5	SCA + LEA	115.0/54.2	52.9	76.01/79.88	-4.8	50% No. 6 Oil, 50% Gas

Figure 3-4 shows similar trends in NO emissions for varying Φ_B and O_2 at a higher load. The same degree of staging could not be achieved at the intermediate load because of fan capacity limitations, however, the curves in Figure 3-4 indicate that roughly the same NO_x reductions would have been obtained had the minimum Φ_B values of Figure 3-3 been reached.

The results of another test series in which overall oxygen and burner equivalence ratio were kept constant while varying staged air insertion height are shown in Figure 3-5. (The staged air height is defined as the height above the heater floor at which the staged combustion air is injected. This is approximately equal to the height above the burner gas tips and oil gun.) There was little, if any, effect of staging height on NO emissions. Since the burner tile top was about 0.23 m (0.75 ft) above the floor of the furnace and since the staged air pipes were located on a diameter outside that of the burner tile injection heights of less than about one foot above the heater floor resulted in impingement of the staged air on the burner tile. Thus, the minimum staging height was approximately 0.3 m (one foot).

Initially, the use of staged combustion when firing No. 6 oil with gas did not produce as large a percentage decrease in NO_x emissions as it did when firing adsorber gas only. The absolute amount of NO_x reduction, however, was about the same for combined fuel firing as it was for gas alone. For example, for the case of staged combustion air combined with lowered excess air firing oil and gas, the NO level dropped from a baseline of 219 ppm, dry corrected to 3 percent O_2, to 166 ppm, dry at 3 percent O_2 for a drop of 53 ppm or 24 percent. For the same conditions firing adsorber gas only at the intermediate load the drop was 46 ppm.

This behavior indicates that fuel nitrogen conversion to NO_x was reponsible for a large fraction of the observed emissions when firing the oil/gas mixture. It appears then that approximately half of the baseline NO_x emission firing oil with gas is due to fuel nitrogen and half is due to thermal NO_x since NO emissions firing this mixture were about twice those observed firing a nitrogen-free refinery gas. The estimated fuel nitrogen conversion efficiency, based on the ratio of oil to gas in the fuel and the oil fuel nitrogen content (~0.8%), is approximately 19 percent.

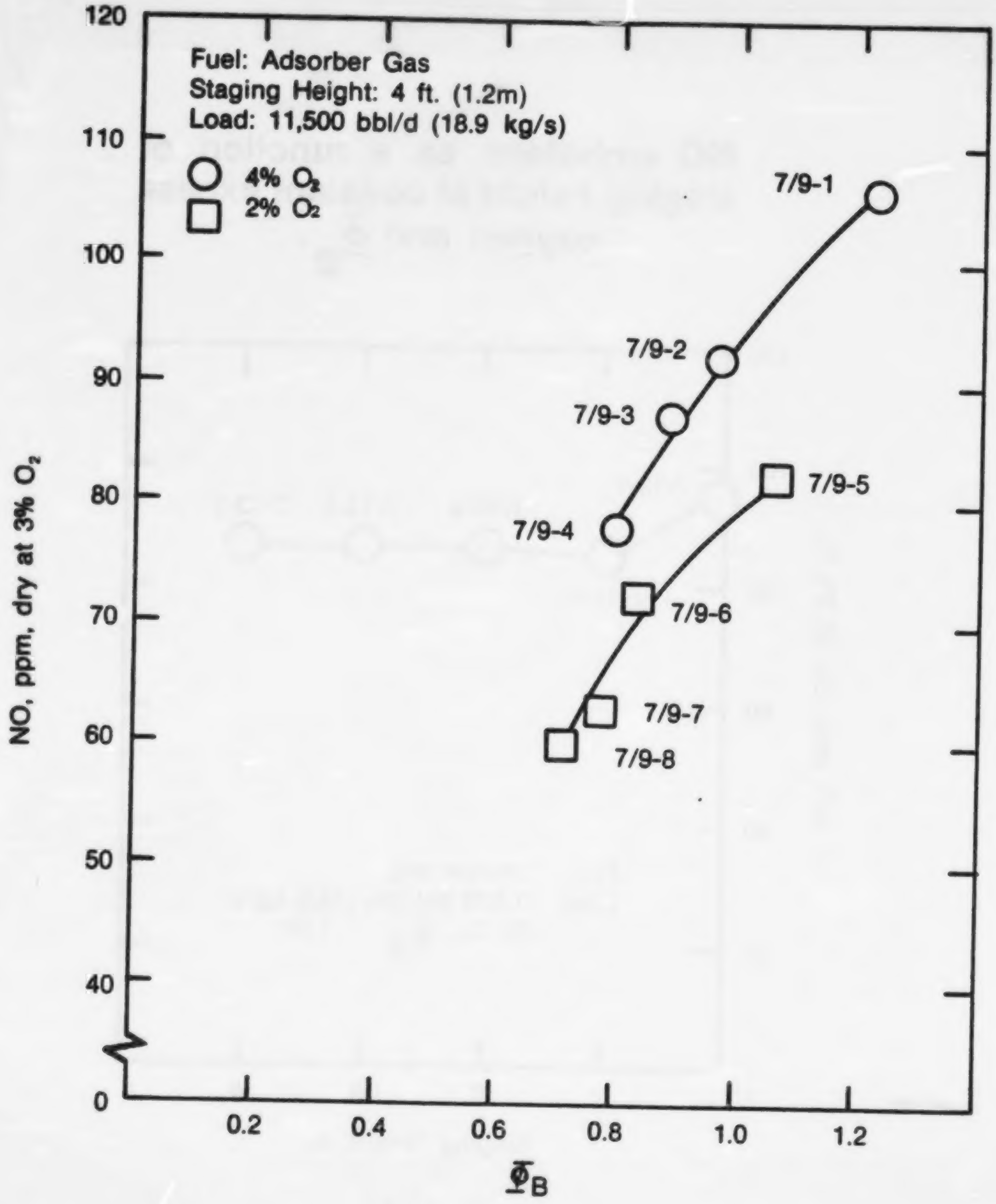

Figure 3-4. NO emissions at 70 percent rated capacity as a function of burner equivalence ratio at two oxygen levels with constant staged air insertion height.

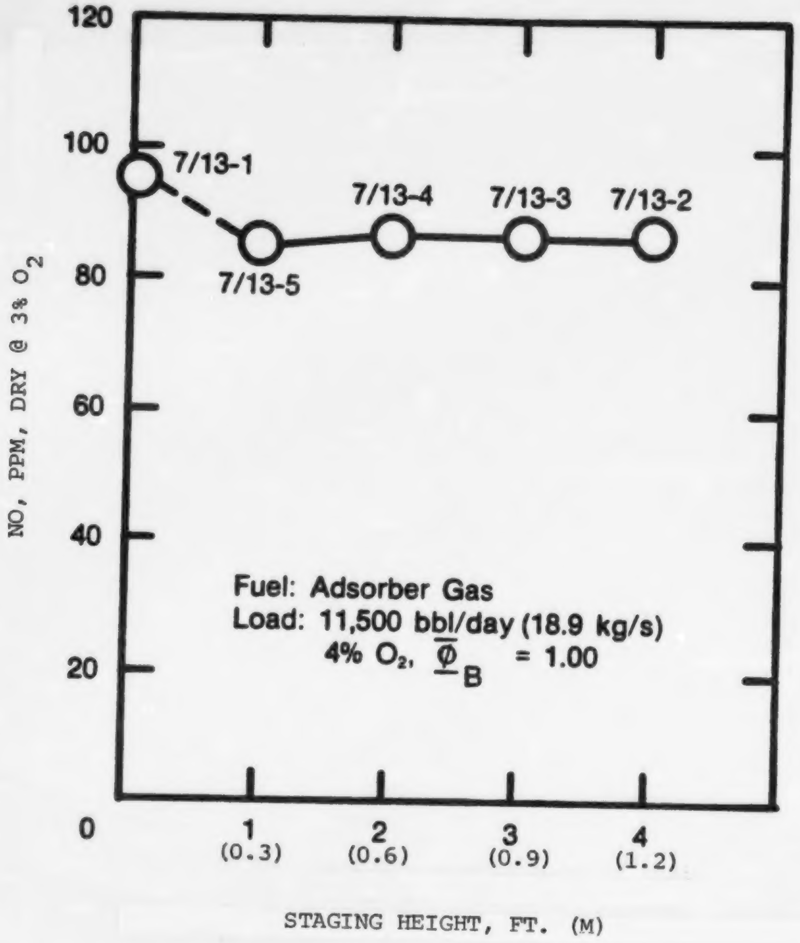

Figure 3-5. NO emissions as a function of staging height at constant oxygen and $\overline{\Phi}_B$.

In subsequent tests of the staged air lances, a larger fan was used to provide a greater air flow rate thereby increasing the amount of staging possible. The goal was to attain a NO_x reduction which was comparable in terms of percent below baseline to the reductions obtained for gaseous fuels.

Figure 3-6 shows the results of the second set of NO emission measurements taken over a range of burner equivalence ratios while operating the larger staged air system. It is important to note that at no time during these tests (or for those with gaseous fuel and the smaller fan) were any appreciable amounts of CO measured. It was found during these tests that closing the secondary air registers increased the effectiveness of the staged air system by further reducing NO emissions. This operating change also increased the furnace draft thus allowing more air to be introduced via the staged air lances without the danger of pressurizing the firebox. In addition, orienting the lance tips such that they faced radially outward from the burner (turned 180 degrees from their normal position) also reduced NO_x emissions. An optimum lance orientation was found which produced low NO_x emissions and minimal flame impingement on the process tubes. This orientation had the lance tips facing inward toward the vertical centerline of the heater (not each burner). This kept the flame away from the walls of the firebox while minimizing the direct injection of the staged air into a flame. This tip orientation was used successfully in the long-term test of the staged air system.

NO_x emissions were reduced from a baseline of about 115 ng/J at 4 percent stack O_2 to a minimum of 54 ng/J at $\Phi_B = 0.60$ (maximum amount of staged air). The reduction was thus 53 percent below the level at the normal operating stack O_2 and 35 percent below the unmodified heater NO emission at 2 percent stack O_2. The efficiency increased from 76.01 percent at baseline to 79.88 percent at the maximum staged air, low O_2 conditions implying a fuel savings of 4.8 percent.

Figure 3-7 shows that NO_x emission decreased slightly as staging height increased firing oil with gas. Very little decrease was observed at heights greater than 1.2 m (4 feet).

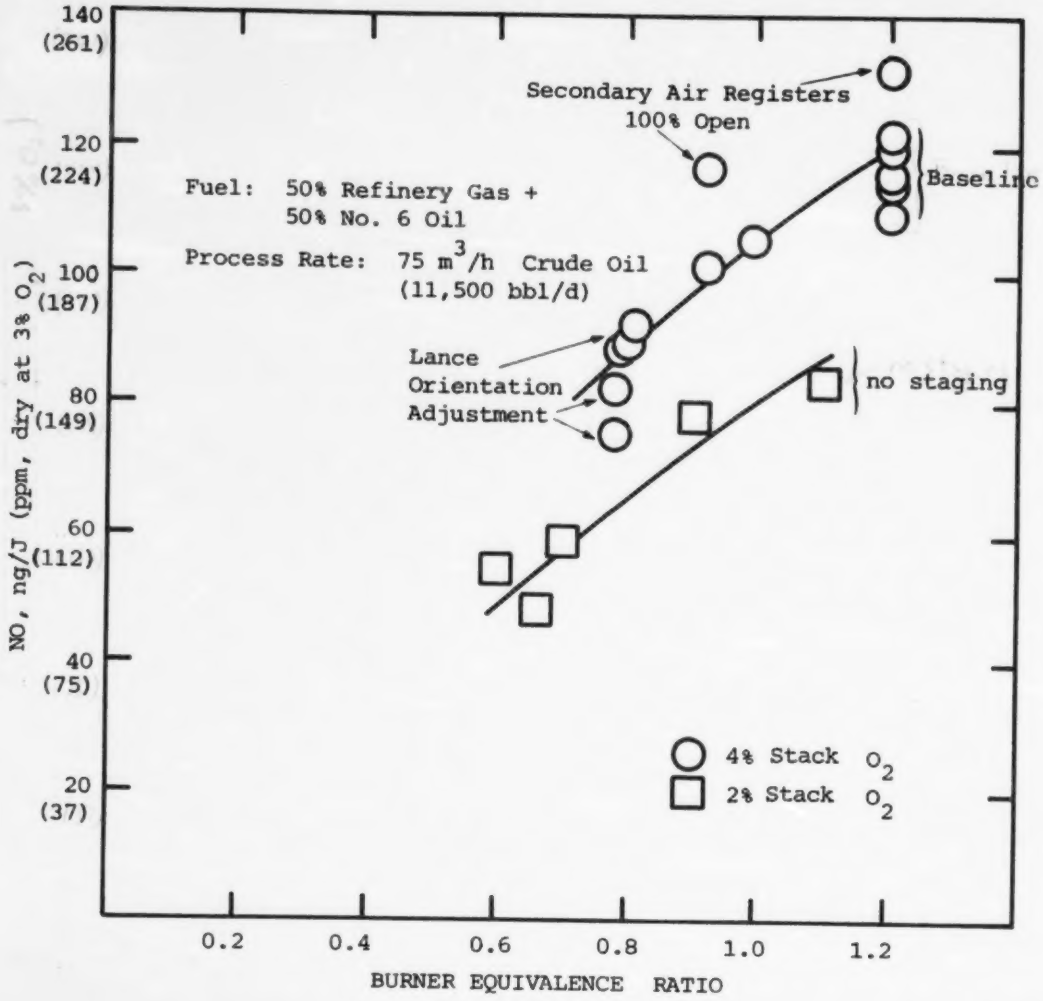

Figure 3-6. NO emissions as a function of burner stoichiometric ratio at two levels of stack oxygen.

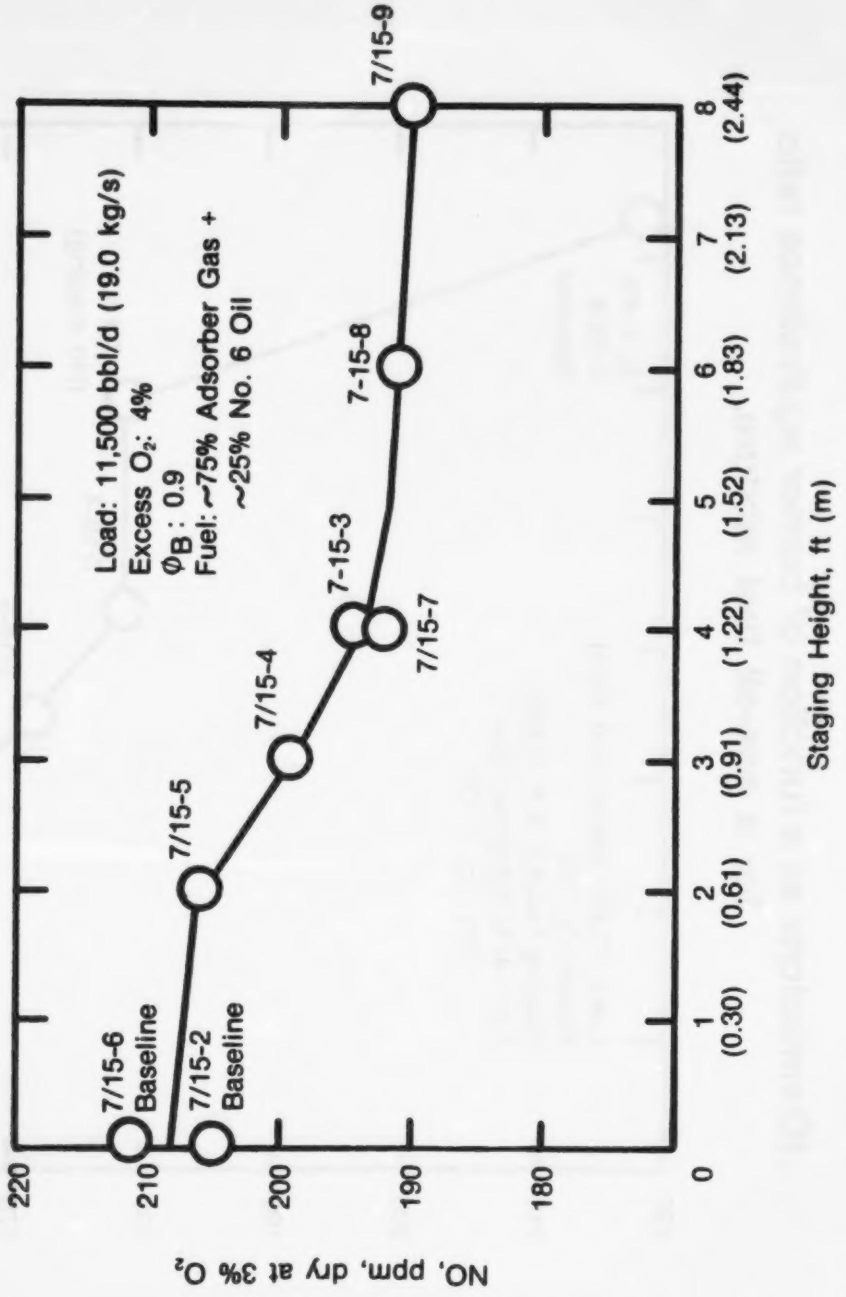

Figure 3-7. NO emission as a function of staging height for gas-oil fuel mixture.

During all testing with the staged combustion system operating, careful observation of the flame and furnace draft was made. There did not appear to be any problems with coking of the process tubes and at no time was there any emission of carbon monoxide or unburned hydrocarbons even at 2 percent stack oxygen. There were certain instances in which the draft in the convection became slightly positive at the low O_2 condition with maximum staging, however, flashback was never observed. The long-term effect of this change in furnace draft in terms of maintenance or operational costs is thought to be small based on the results of a 30-day test conducted on the heater with the large staged air fan operating at maximum capacity.

3.3 STEAM INJECTION FIRING GASEOUS FUEL

As indicated in Table 3-1, steam injection through the oil gun of each burner while firing adsorber gas produced little or no change in NO emission while decreasing thermal efficiency. A plot of NO emission versus steam injection is presented in Figure 3-8.

Tests of steam injection while firing No. 6 oil (additional to the steam required to atomize the oil) were not attempted because of the complexity and cost of the hardware modifications which would nave been necessary.

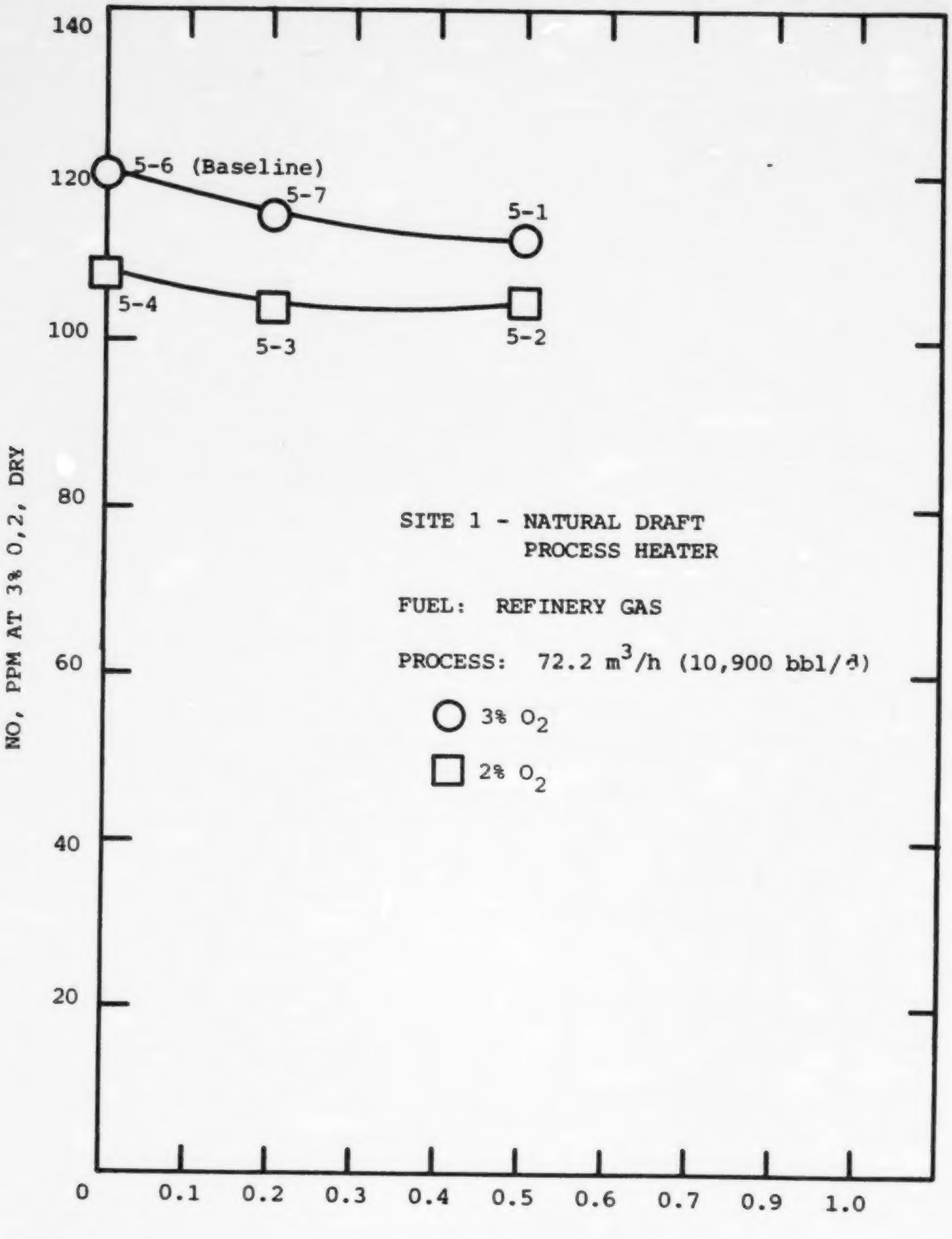

Figure 3-8. NO emissions as a function of steam injection ratio at two levels of oxygen.

SECTION 4.0

RESULTS OF LONG-TERM TESTS OF STAGED COMBUSTION AIR

This section presents the results of a continuous monitor test to evaluate the long-term gaseous emissions from the gas-fired petroleum process heater which had been modified for staged combustion. The objective of the test was to provide gaseous emissions data from the 107.7 m^3/h (16,250 bbl/day) natural draft petroleum process heater for a test duration of 30 days. The gaseous emissions measured were NO, O_2, CO_2 and CO. The following sections describe the continuous monitor certification tests and discuss the results of the 30-day test.

4.1 MONITOR CERTIFICATION TESTS

The mobile laboratory described in Appendix A was used to measure the gaseous emissions. Monitoring system certification tests were performed in accordance with Performance Specifications 2 (PS 2) and 3 (PS 3), 40 CFR 60. These establish minimum performance specifications that the NO monitoring system must meet in terms of eight parameters: accuracy, calibration error, two- and 24-hour zero drifts, two- and 24-hour calibration drifts, response time and operational period.

The mobile laboratory was used for this test since it had been used for the parametric tests and sample lines and electrical power were already installed. The monitor performance certification began on April 29, 1981. A daily event schedule for the certification tests is shown in Table 4-1. The results of the monitor certification tests are summarized in Table 4-2. The relative accuracy value for the NO analyzer includes only the results of the second set of Method 7 PDS flasks taken on May 28, 1981. After the results of the first set of Method 7 flasks were received by telephone, the relative accuracy was calculated and found to be greatly different from any previous relative accuracy measurements. The initial relative accuracy was calculated to be 44.4 percent. KVB felt strongly that the error was in the PDSA analysis

TABLE 4-1. SCHEDULE OF CERTIFICATION TEST EVENTS

Date	Time	Event
4-29-81	0900	Instrument response time tests (NO, CO, O_2)
4-30-81	1200	Initial 24 hour zero and span reading
		Initial 2 hour zero and span reading
4-30-81	1400	1st 2 hour zero and span drift point
	1600	2nd 2 hour zero and span drift point
	1800	3rd 2 hour zero and span drift point
	2000	4th 2 hour zero and span drift point
	2200	5th 2 hour zero and span drift point
5-01-81	0800	Initial 2 hour zero and span drift reading
	1000	6th 2 hour zero and span drift point
	1200	7th 2 hour zero and span drift point
	1200	1st 24 hour zero and span drift point
	1230	Initial 2 hour zero and span drift reading
	1430	8th 2 hour zero and span drift point
	1630	9th 2 hour zero and span drift point
	1830	10th 2 hour zero and span drift point
5-02-81	0800	Initial 2 hour zero and span drift reading
	1000	11th 2 hour zero and span drift point
	1200	12th 2 hour zero and span drift point
	1200	2nd 24 hour zero and span drift point
	1230	Initial 2 hour zero and span drift reading
	1430	13th 2 hour zero and span drift point
	1630	14th 2 hour zero and span drift point
	1830	15th 2 hour zero and span drift point
5-03-81	1200	3rd 24 hour zero and span drift point
5-04-81	1200	4th 24 hour zero and span drift point
5-05-81	1200	5th 24 hour zero and span drift point
5-06-81	1200	6th 24 hour zero and span drift point
5-06-81	0900-1700	Relative accuracy test
5-07-81	1200	7th 24 hour zero and span drift point
5-13-81	0900	Instrument response time test (CO_2)
5-13-81	0930	Calibration error determination
5-28-81	0730-1530	Relative accuracy tests

TABLE 4-2. INSTRUMENT SPECIFICATIONS AND PERFORMANCE

Modified Process Heater 30-day Test

Parameter	Specifications	Performance
A. Thermo Electron Series 10 NO_x Analyzer		
1. Calibration error mid	$\leq$ 5% of cal gas value	1.3%
high	$\leq$ 5% of cal gas value	0.4%
2. Accuracy	$\leq$ 20% of mean ref. value	11.9%
3. Zero drift (2 hour)	2% of span	0.11%
4. Zero drift (24 hour)	2% of span	0.49%
5. Calibration drift (2 hour)	2% of span	0.38%
6. Calibration drift (24 hour)	2.5% of span	2.0%
7. Response time	15 minute maximum	10 sec
8. Operational period	168 hour minimum	168 hr
B. Horiba Instruments PIR 2000 CO_2 Analyzer		
1. Calibration error mid	$\leq$ 5% of cal gas value	1.62%
high	$\leq$ 5% of cal gas value	0.78%
2. Zero drift (2 hour)	$\leq$ 0.4 pct CO_2	0%
3. Zero drift (24 hour)	$\leq$ 0.5 pct CO_2	0.3%
4. Calibration drift (2 hour)	$\leq$ 0.4 pct CO_2	0%
5. Calibration drift (24 hour)	$\leq$ 0.5 pct CO_2	0.3%
6. Response time	10 minutes	15 sec
7. Operational period	168 hour minimum	168 hr
C. Teledyne Model 326A O_2 Analyzer		
1. Calibration error mid	$\leq$ 5% of cal gas value	1.54%
high	$\leq$ 5% of cal gas value	1.44%
2. Zero drift (2 hour)	$\leq$ 0.4 pct O_2	0.04%
3. Zero drift (24 hour)	$\leq$ 0.5 pct O_2	0.1%
4. Calibration drift (2 hour)	$\leq$ 0.4 pct O_2	0.12%
5. Calibration drift (24 hour)	$\leq$ 0.5 pct O_2 (15% of span)	0.06%
6. Response time	10 minutes	37 sec
7. Operational period	168 hour minimum	168 hr
D. Beckman Model 865 CO Analyzer		
1. Calibration error mid	$\leq$ 5% of cal gas value	0.4%
high	$\leq$ 5% of cal gas value	0.6%
2. Zero drift (2 hour)	2% of span	0.13%
3. Zero drift (24 hour)	2% of span	0.3%
4. Calibration drift (2 hour)	2% of span	0.27%
5. Calibration drift (24 hour)	2.5% of span	0.5%
6. Response time	15 minute maximum	29 sec
7. Operational period	168 hour minimum	168 hr

rather than the chemiluminescent analyzer. Therefore, a second aliquot was analyzed before the results were submitted to KVB. These results were substantially the same as the preliminary results reported over the telephone. However, samples of the span gas were submitted with the flue gas samples and the analysis of the span gas showed a large error relative to the cylinder certified analysis. The span gas concentrations was certified to be 143 ppm NO (147.5 ppm NO_x), 12.68 percent CO_2 with the balance N_2. This represents about a 25 percent error relative to the PDS analysis. Samples of the span gas were then sent to another laboratory for analysis by the PDSA method. These analyses resulted in an average of 135 ppm NO_x which represents about a 9 percent error. The results of these analyses, as well as all of the other certification data sheets, are presented in Appendix C. A span gas was then obtained with a ±1% analysis, traceable to the National Bureau of Standards. The NBS traceable gas, two certified span gases and a zero gas were then connected to the analyzer for a check of span value. The instrument was calibrated with the NBS traceable span gas, then alternately zeroed and spanned with the original span gases. The span gas used for the Method 7 tests showed an error of less than 1 ppm. Based on these tests, it was concluded that the PDSA analyses were probably in error. The second set of Method 7 tests resulted in a relative accuracy of 11.9 percent which is well within the PS 2 value of 20 percent.

4.2 GASEOUS EMISSIONS TEST RESULTS

Gaseous emissions were measured continuously and recorded on an automatic data logger, strip chart recorders and a magnetic tape recorder. The data logger was programmed to scan every four seconds and print 15-minute averages. This provides 225 measurements for each averaging period except those periods when the instruments are being calibrated. The strip chart recorders are used to verify the data logger tapes and to fill any gaps in the data from the data logger, should they occur. Daily tabulations of the unit operating data were provided by a KVB technician on-site. A daily log was also kept with comments relative to unit operation and continuous monitor operation. The emissions and unit operating data are tabulated in a format for input to a computer program for compiling and data analysis. A preliminary screening of the data is performed prior to input to the computer program.

After the preliminary screening, the data were input to the computer and daily 15-minute averages were compiled. The format in which the 15-minute averages are reported is shown in Table 4-3. Twenty four-hour averages were then computed for the entire test period. A summary of the 24-hour averages is presented in Table 4-4. A complete listing of the 15-minute averages is included in Appendix D.

Baseline tests to measure gaseous emissions were conducted without staged air before and after the 30-day test. The NO emissions were 120 ppm, dry at 3% O_2 and 130 ppm, respectively, for an average of 125 ppm. This represents a higher baseline level firing adsorber gas than had been measured a year earlier during parametric tests presumably due to changes in fuel and heater characteristics.

After conducting baseline tests to measure the gaseous emissions without SCA, the staged air system was activated and the flue gas excess oxygen was lowered to approximately 2 percent with the concurrence of the refinery operating personnel. The stack oxygen was monitored continuously in the mobile emissions laboratory and variations in O_2 were reported to the heater operators by a KVB technician. The burner stoichiometric ratio, Φ_B, at this O_2 level was 0.60. This represented maximum staging capability. The heater was then operated in this mode steadily for 15 days. After approximately 15 days, a change in the crude charge specific gravity required an increase in firing rate*. Since there are no automatic controls on the heater, the increase in fuel flow resulted in a deficiency in oxygen and high CO values. The operators responded by opening the dampers completely resulting in large values of excess oxygen. Figure 4-1 shows the daily average excess oxygen with increasing O_2 at about the 16th day. Efforts were made to reduce the O_2 to the previous 2 percent level. Due to the changing

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*Crude stack changes occurred routinely approximately every other day, however, in this case the change was apparently more drastic than usual.

TABLE 4-3.

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD bbl/day*	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 3/81	15	10717.0	2.5	11.7	10	45	9	43	3	23	
5/ 3/81	30	10717.0	2.6	11.7	10	44	9	43	3	23	
5/ 3/81	45	10717.0	2.5	11.7	10	44	9	42	3	23	
5/ 3/81	100	10717.0	2.5	11.7	12	45	11	43	3	23	
5/ 3/81	115	10717.0	2.6	11.7	11	45	10	44	3	23	
5/ 3/81	130	10717.0	2.6	11.7	9	45	8	44	2	23	
5/ 3/81	145	10717.0	2.6	11.7	9	45	8	44	2	23	
5/ 3/81	200	10717.0	2.6	11.7	7	45	6	44	2	23	
5/ 3/81	215	10717.0	2.5	11.7	8	45	7	43	2	23	
5/ 3/81	230	10717.0	2.4	11.8	8	46	7	44	2	24	
5/ 3/81	245	10717.0	2.6	11.7	10	46	9	44	3	24	
5/ 3/81	300	10717.0	2.6	11.7	9	46	8	44	2	24	
5/ 3/81	315	10717.0	2.8	11.5	9	49	8	48	2	26	
5/ 3/81	330	10717.0	2.7	11.6	11	48	10	47	3	25	
5/ 3/81	345	10717.0	2.7	11.6	10	47	9	46	3	25	
5/ 3/81	400	10717.0	2.6	11.7	10	46	9	44	3	24	
5/ 3/81	415	10717.0	2.5	11.7	11	46	10	44	3	24	
5/ 3/81	430	10717.0	2.4	11.8	8	45	7	43	2	23	
5/ 3/81	445	10717.0	2.6	11.7	10	46	9	44	3	24	
5/ 3/81	500	10717.0	2.6	11.7	9	46	8	44	2	24	
5/ 3/81	515	10717.0	2.6	11.7	12	46	11	44	3	24	
5/ 3/81	530	10717.0	2.6	11.7	11	47	10	45	3	24	
5/ 3/81	545	10717.0	2.7	11.6	10	47	9	46	3	25	
5/ 3/81	600	10717.0	2.7	11.6	10	47	9	46	3	25	
5/ 3/81	615	10717.0	2.7	11.6	15	46	14	45	4	24	
5/ 3/81	630	10717.0	2.7	11.6	16	46	15	45	5	24	
5/ 3/81	645	10717.0	2.7	11.6	16	46	15	45	5	24	
5/ 3/81	700	10717.0	2.8	11.5	17	47	16	46	5	25	
5/ 3/81	715	10717.0	2.7	11.6	16	47	15	46	5	25	
5/ 3/81	730	10717.0	2.7	11.6	15	48	14	47	4	25	
5/ 3/81	745	10717.0	2.7	11.6	15	48	14	47	4	25	
5/ 3/81	800	10717.0	2.7	11.6	14	47	13	46	4	25	
5/ 3/81	815	10717.0	2.6	11.7	14	46	13	44	4	24	
5/ 3/81	830	10717.0	2.4	11.8	13	47	12	45	4	24	
5/ 3/81	845	10717.0	2.3	11.9	16	47	15	45	5	24	
5/ 3/81	900	10717.0	2.4	11.8	16	47	15	45	5	24	
5/ 3/81	915	10717.0	2.5	11.7	15	46	14	44	4	24	
5/ 3/81	930	10717.0	2.5	11.7	15	45	14	43	4	23	
5/ 3/81	945	10717.0	2.3	11.9	15	45	14	43	4	23	
5/ 3/81	1000	10717.0	2.4	11.8	17	46	16	44	5	24	
5/ 3/81	1015	10717.0	2.5	11.7	17	47	16	45	5	24	
5/ 3/81	1030	10717.0	2.5	11.7	18	47	17	45	5	24	
5/ 3/81	1045	10717.0	2.4	11.8	16	48	15	46	5	25	
5/ 3/81	1100	10717.0	2.3	11.9	16	47	15	45	5	24	
5/ 3/81	1115	10717.0	2.3	11.9	15	46	14	44	4	24	
5/ 3/81	1130	10717.0	2.2	11.9	17	45	16	43	5	23	
5/ 3/81	1145	10717.0	2.0	12.0	17	46	16	43	5	23	
5/ 3/81	1200	10717.0	1.9	12.0	17	46	16	43	5	23	

* barrels/day

TABLE 4-4

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
24 HOUR DATA
DRY STACK GAS CONCENTRATION

DATE	LOAD bbl/day*	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
5/ 1/81	10717.0	1.6	12.3	8	35	7	32	2	17
5/ 2/81	10717.0	2.1	12.0	11	43	10	40	3	22
5/ 3/81	10717.0	2.3	11.9	11	45	10	43	3	23
5/ 4/81	10717.0	2.2	11.9	13	44	12	42	4	22
5/ 5/81	10717.0	2.3	11.9	28	42	26	40	8	21
5/ 6/81	10717.0	2.5	11.7	9	44	8	42	2	23
5/ 7/81	10717.0	2.7	11.6	28	43	27	42	9	22
5/ 8/81	10717.0	2.2	11.9	6	39	5	37	1	20
5/ 9/81	10717.0	1.9	11.8	13	36	12	33	4	18
5/10/81	10717.0	1.6	12.3	13	32	12	29	3	16
5/11/81	11178.7	1.6	12.3	43	32	39	29	13	16
5/12/81	10717.0	1.4	12.4	9	30	8	27	2	14
5/13/81	10717.0	1.7	12.2	5	32	4	29	1	16
5/14/81	10717.0	1.6	12.2	12	33	11	30	3	16
5/15/81	10717.0	1.6	12.1	12	32	11	29	3	16
5/16/81	10717.0	3.9	10.5	70	55	73	57	24	31
5/17/81	10717.0	6.8	8.9	7	79	8	100	2	54
5/18/81	10717.0	3.6	10.8	209	48	216	49	71	26
5/19/81	10717.0	3.3	10.8	95	49	96	49	31	27
5/20/81	10717.0	1.6	11.9	55	31	51	28	16	15
5/21/81	10717.0	2.4	11.7	11	36	10	34	3	18
5/22/81	10717.0	2.5	11.7	48	36	46	34	15	18
5/23/81	10717.0	4.4	10.5	20	50	21	54	7	29
5/24/81	10717.0	2.1	12.0	20	43	19	41	6	22
5/25/81	10717.0	3.3	11.3	98	43	99	43	32	23
5/26/81	10717.0	4.2	10.7	7	45	7	48	2	26
5/27/81	10717.0	4.2	10.6	8	45	8	48	2	26
5/28/81	10717.0	4.1	10.4	5	46	5	49	1	26
5/29/81	10717.0	3.8	10.8	10	51	10	53	3	28
5/30/81	10717.0	3.9	10.8	13	49	13	51	4	27
5/31/81	10717.0	3.9	10.8	12	45	12	47	4	25
6/ 1/81	10717.0	3.7	10.8	8	45	8	46	2	25
6/ 2/81	10717.0	3.9	10.6	6	46	6	48	2	26

* barrels/day

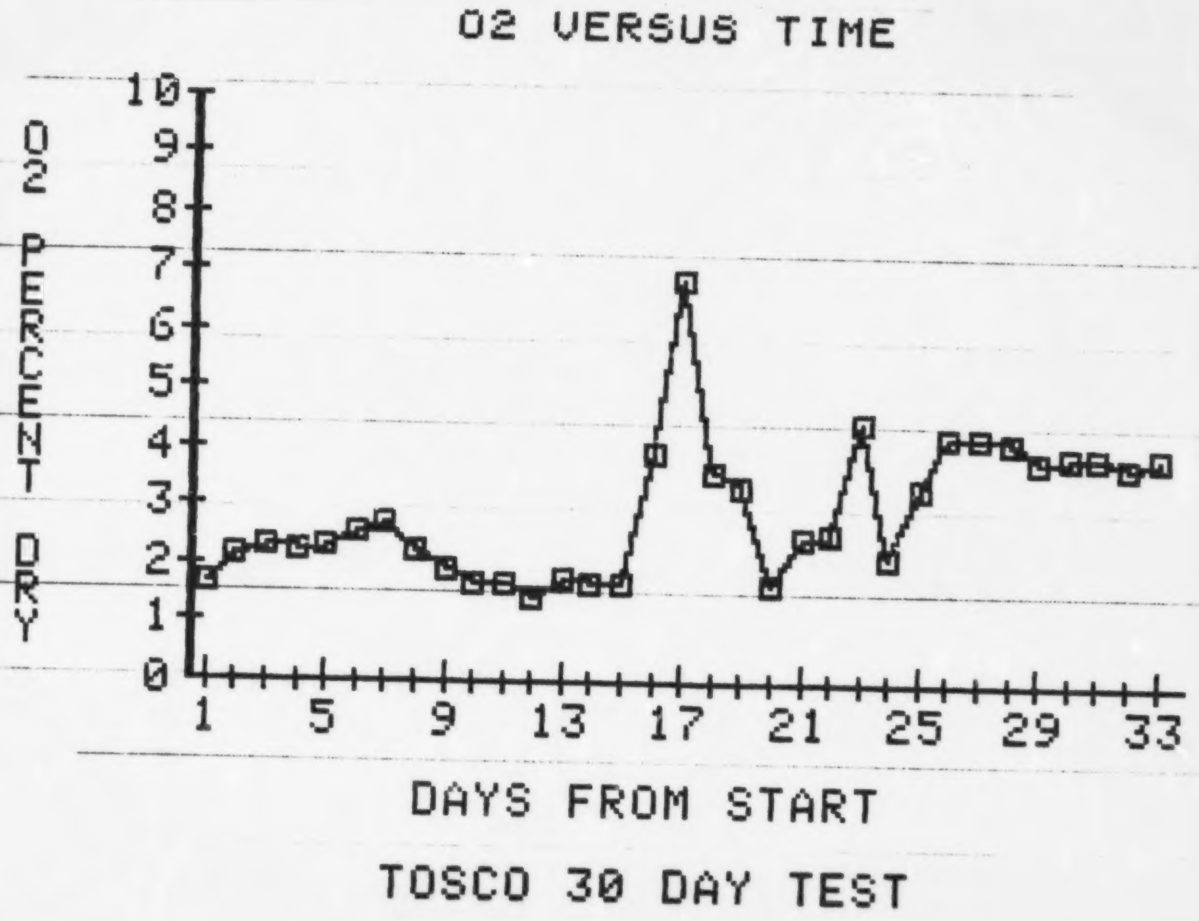

Figure 4-1. Stack Oxygen as a Function of Time from Start of Test

conditions, and lack of automatic controls, it was decided to operate the remainder of the test at about 4 percent oxygen. The lowest attainable Φ_B at this level was 0.70. The flue gas 24-hour average CO concentration is shown in Figure 4-2 for the test period. The highest 24-hour average CO concentration is 216 ppm at 3 percent, O_2, dry. Peak values of CO were approximately 1300 ppm. Both O_2 and CO_2 were measured to provide redundant measurements for dilution calculations. Figure 4-3 shows CO_2 concentration as a function of time for the entire test period. The O_2 and CO_2 data were then plotted against one another to assure correlation of the measurements. These data are shown in Figure 4-4. The correlation coefficient for these data is 0.97 which indicates excellent correlation.

The NO concentration as a function of days from the start of testing is presented in Figure 4-5. The peak occurred during the upset condition when O_2 was increased. Even under the high O_2 condition, with the staged air system operating the NO concentration was lower than the baseline level. The NO concentration as a function of O_2 is shown in Figure 4-6. A linear regression analysis of these data showed a good correlation. The correlation coefficient, r^2, is 0.85.

The emission measurements for this heater were also calculated in terms of firing rate. The units for the emission rate are pounds/million Btu or nanograms/Joule. An F-factor was used to calculate the emission rate in the unit of the standard. It reduces the amount of data necesary to complete the emission rate calculation. The F-factor for making emission rate calculations is developed from a chemical and combustion analysis of the fuel burned. The F-factor is the ratio of the theoretical volume of dry gases (V_t) given off by complete combustion of a known amount of fuel, to the gross caloric value of the burned fuel (HHV).

$$F_d = \frac{\text{Volume Dry Combustion Gases}}{\text{Gross Caloric Value}} = \frac{V_t}{\text{HHV}}$$

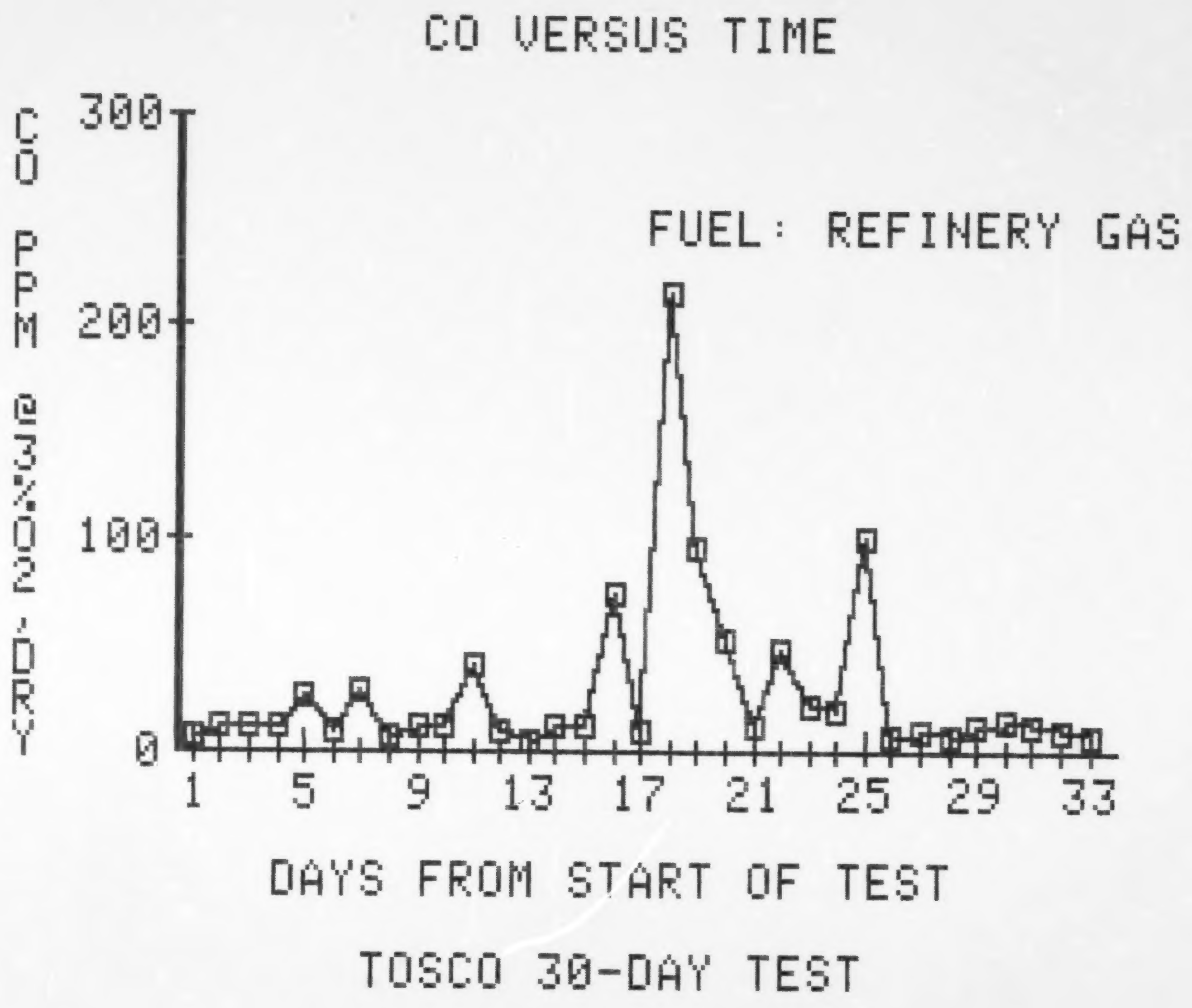

Figure 4-2. CO Concentration as a Function of Time from Start of Test

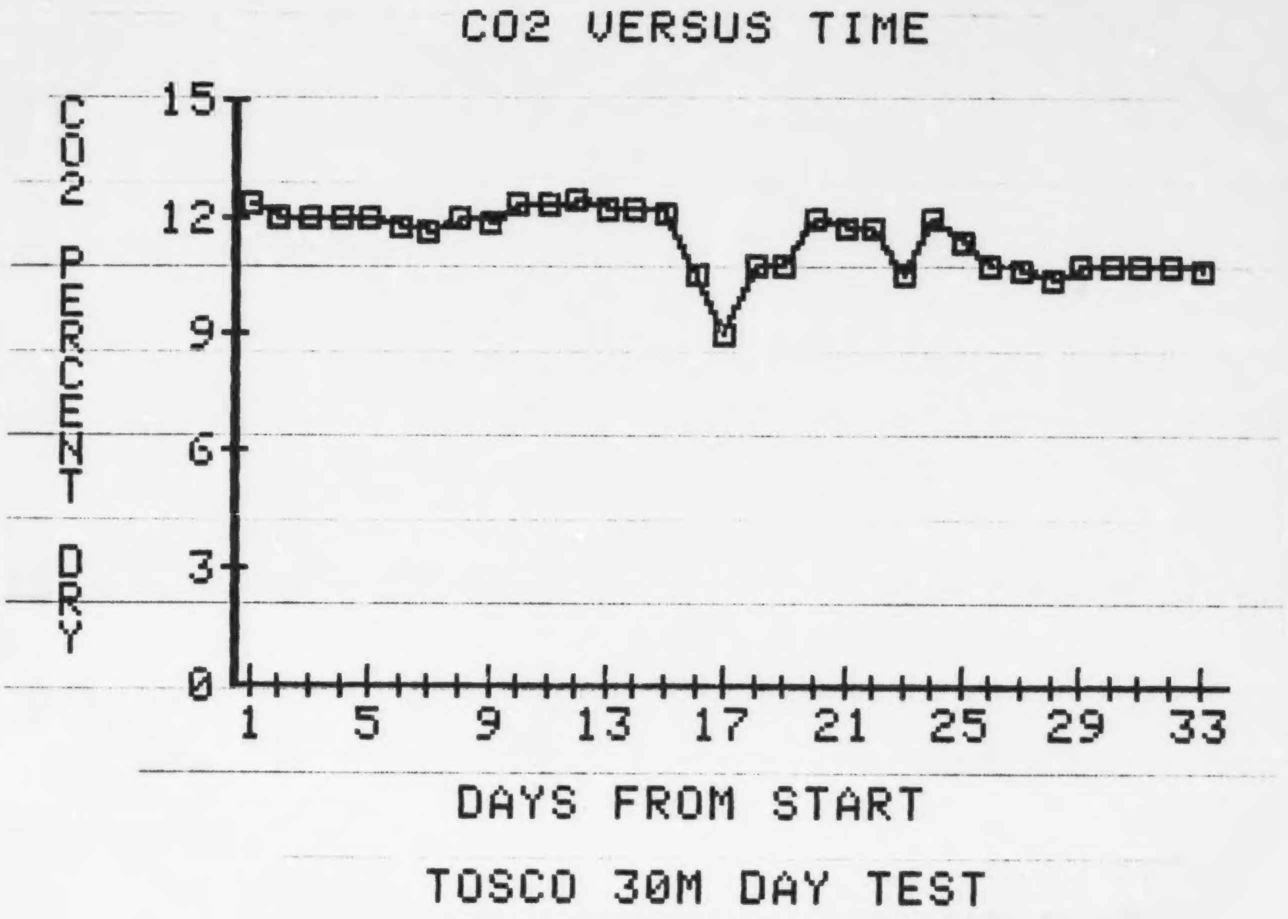

Figure 4-3. CO_2 Concentration as a Function of Time from Start of Test

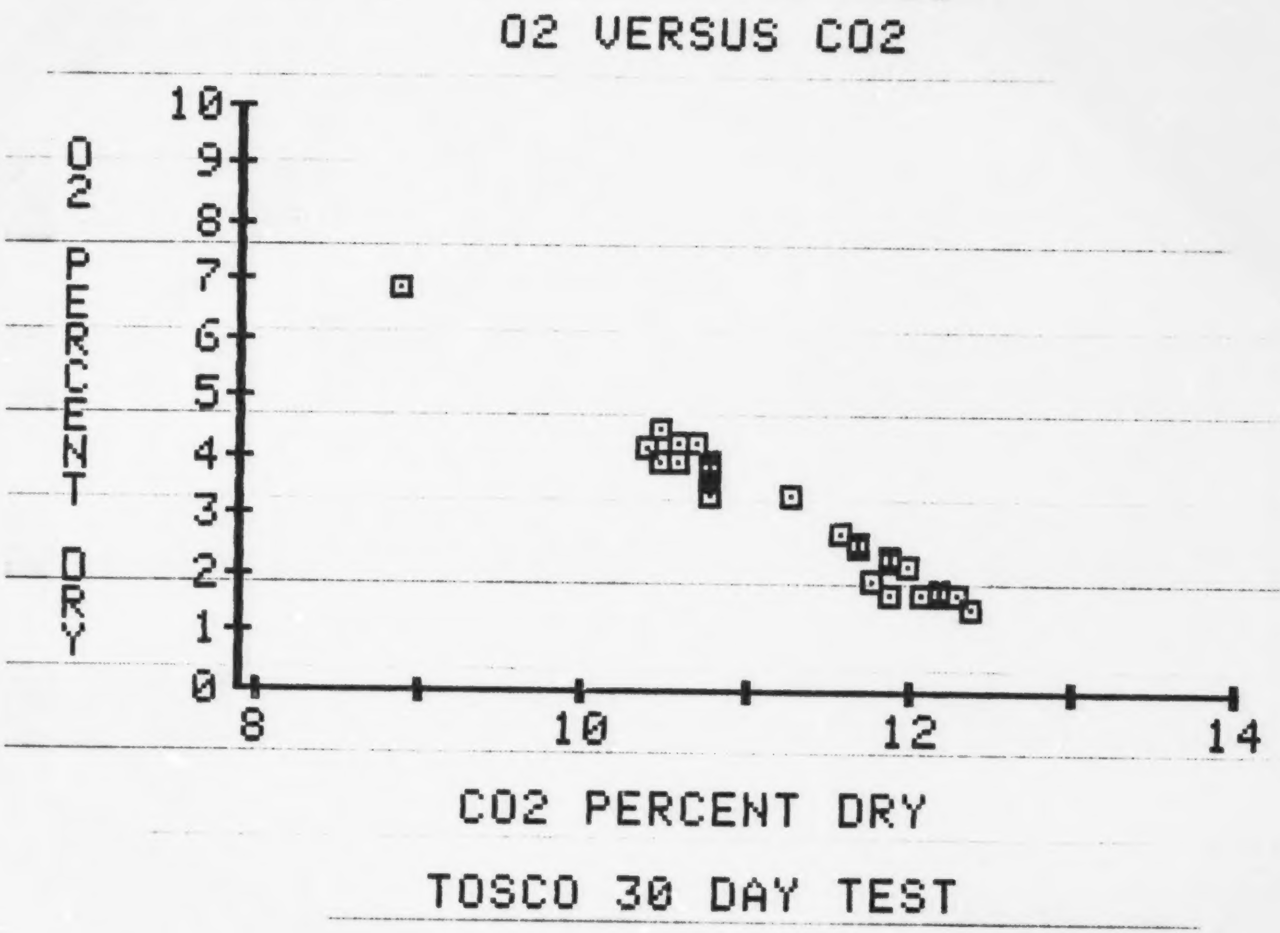

Figure 4-4. Stack Oxygen as a Function of CO_2 Concentration

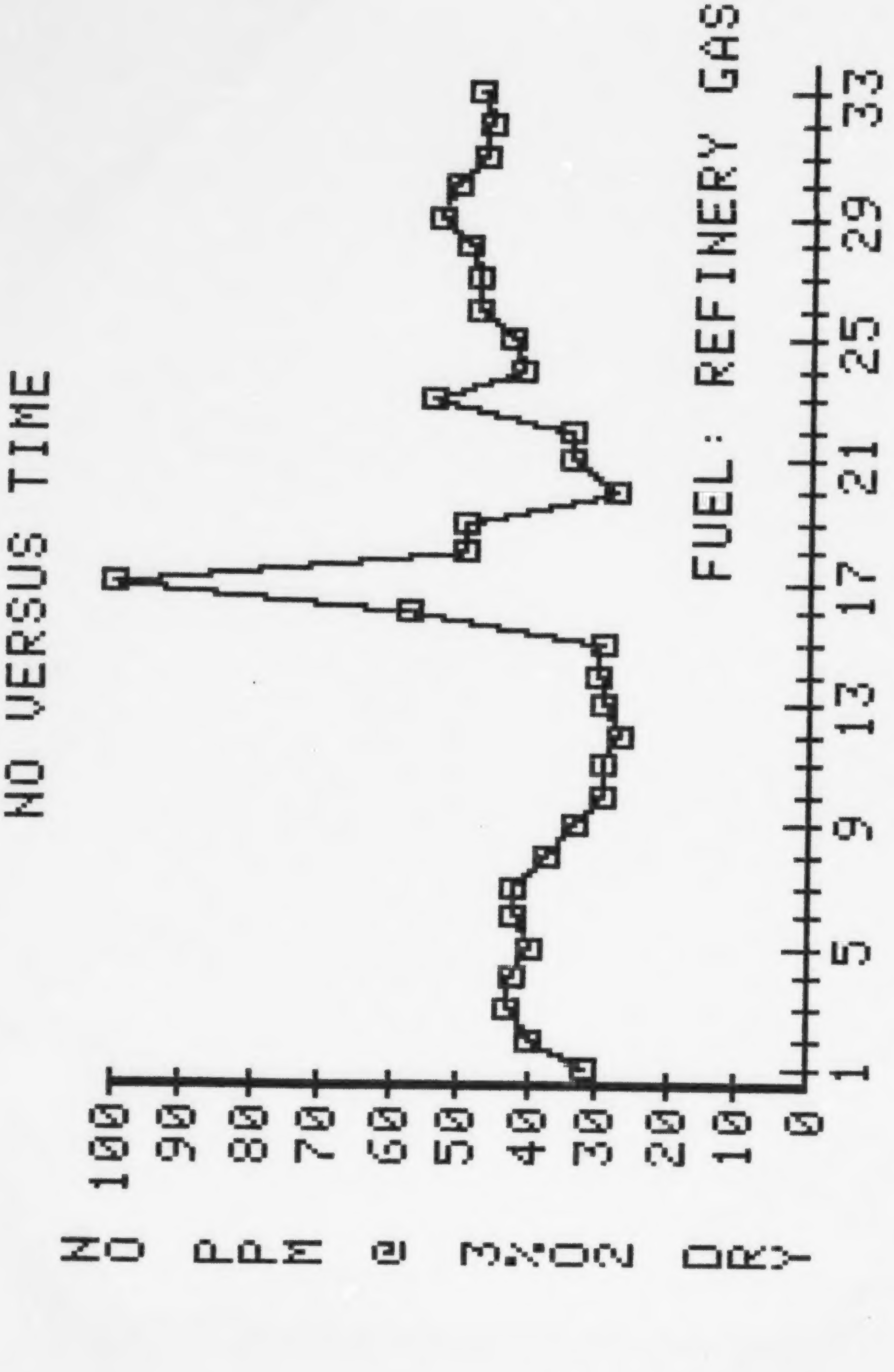

Figure 4-5. NO Concentration as a Function of Time from Start of Test

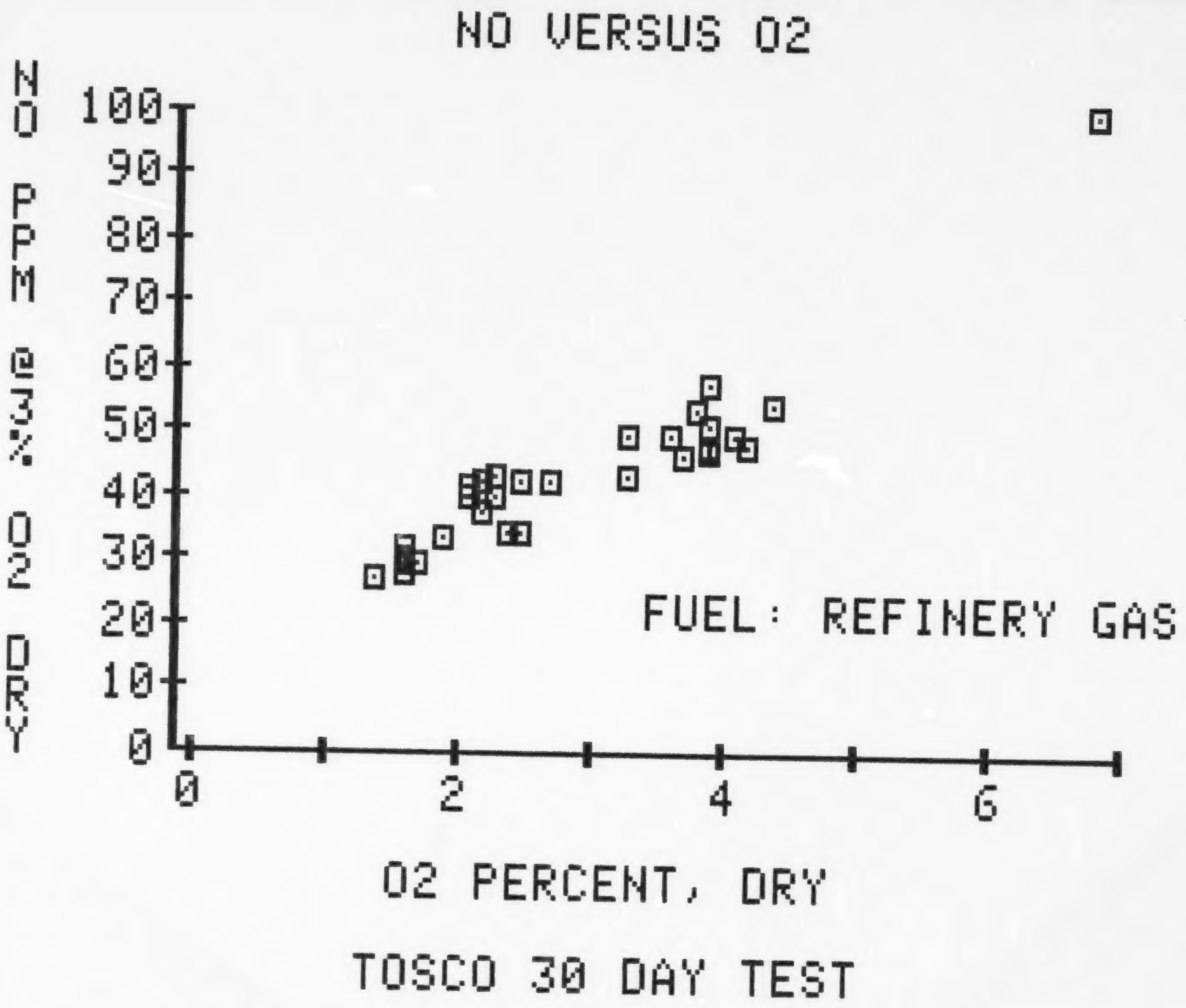

Figure 4-6. NO Concentration as a Function of Stack Oxygen

An ultimate analysis of the fuel allows the calculation of an F_d factor based on the composition of the fuel constituents. Using the average of 15 fuel analyses made during the test period, an F_d factor was calculated to be:

$$F_d = 8577 \frac{\text{dscf}}{10^6 \text{ Btu}} = 2.302 \times 10^{-7} \frac{\text{dscm}}{\text{J}}$$

The average fuel analysis is presented in Table 4-5. (Note that the F-factor for each analysis does not vary significantly from the average F-factor as the standard deviation in Table 4-5 indicates.) The results of all of the fuel analyses made during the 30-day test are given in Appendix E. The emission rate at operating conditions is calculated from the following relationship:

$$E = C_d \, F_d \, \frac{20.9}{20.9 - \% \, O_2}$$

where

E = Pollutant emission rate, lb/10^6 Btu (ng/J)

C_d = Pollutant concentration, lb/dscf (ng/dscm)

F_d = Fuel firing factor, dry basis, dscf/10^6 Btu (dscm/J)

To convert from ppm NO_x to lb/dscf multiply by 1.194×10^{-7}. To convert from ppm NO_x to ng/dscm multipy by 1.912×10^6.

The data for both CO and NO emissions were converted to emission rates and are tabulated in Table 4-4 for the test period.

The NO emission data were then divided into two groups corresponding to 2 percent oxygen and 4 percent oxygen. Graphical analyses of the NO emission rates showed the data to be log-normally distributed. Figure 4-7 presents a normal probability curve of NO emission rate for the nominal 2 percent O_2 condition. The curvature of the data indicates that the data are not normally distributed. The data were then plotted on log-probability paper

TABLE 4-5. SUMMARY OF REFINERY FUEL ANALYSES
(15 Measurements)

Carbon Monoxide	Average %	Standard Deviation
Hydrogen	12.4	0.95
Nitrogen	0.9	0.15
Carbon Monoxide	0.6	0.11
Methane	30.0	1.73
Ethane	17.2	0.73
Ethylene	5.1	0.41
Propane	22.4	1.66
Propylene	3.6	0.37
Isobutane	5.8	1.87
Normal Butane	0.7	0.33
Total Butenes	0.6	0.10
Isopentane	0.2	0.06
Normal Pentane	0.1	0
Total C_6 plus	0.4	0.17
kJ/m^3 (Btu/ft^3)	61,030 (1638)	2493 (66.9)
Specific Gravity	0.9734	0.0434
F (DSCM of Combustion Gas/kJ)	2.302×10^{-4}	0.002×10^{-4}

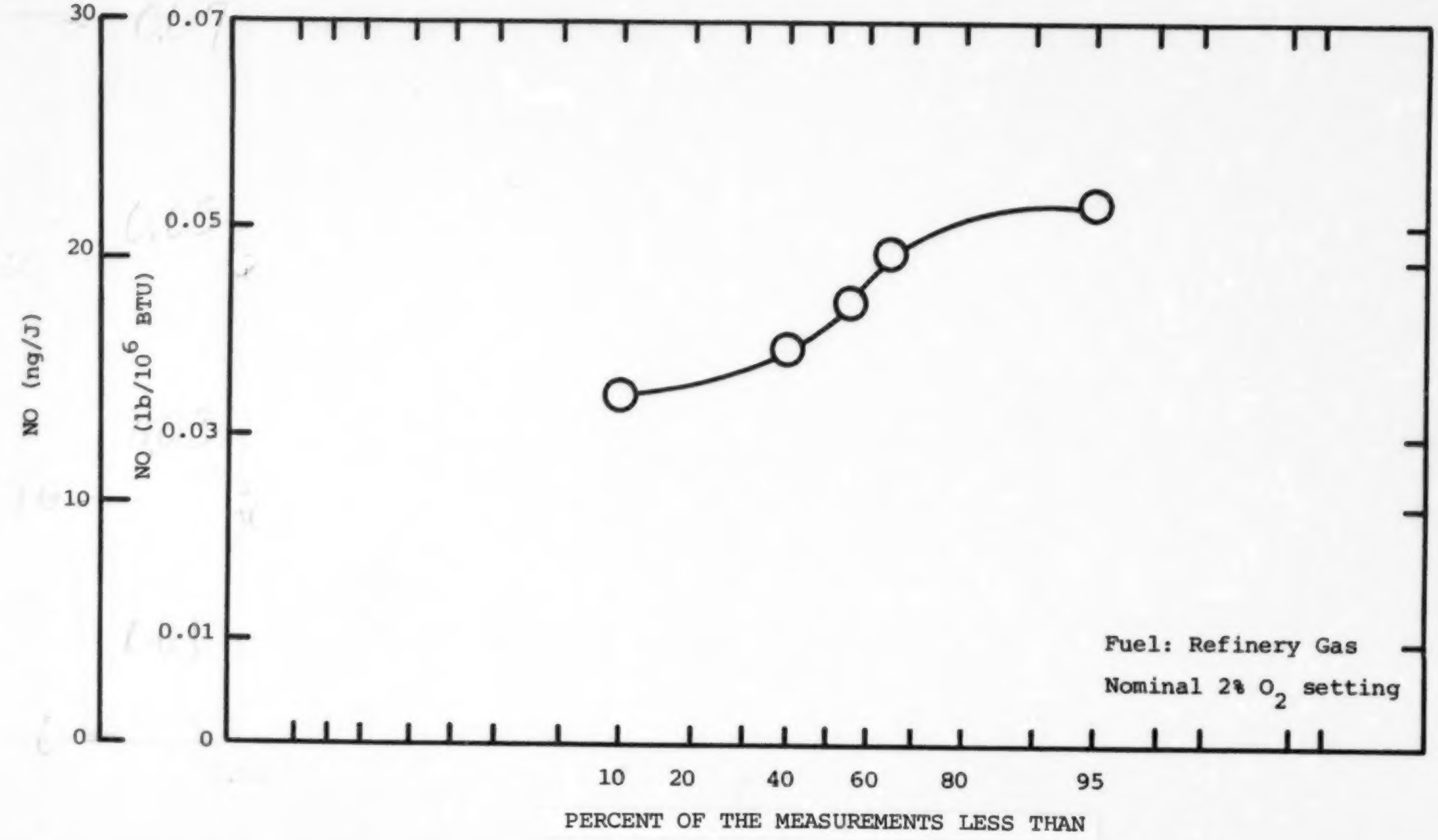

Figure 4-7. Normal probability curve of NO emissions - Process heater 30-day field test

as shown in Figure 4-8. A straight line fits these data well so it was concluded the data are log-normally distributed. This curve shows that the mean value is 18.5 ng/J (0.04 lb/10^6 Btu) for the 2 percent O_2 setting. The nominal 4 percent O_2 condition is shown in Figure 4-9. The mean value of NO emission rate for these data is 25.5 ng/J (0.06 lb/10^6 Btu) with 99 percent of the values less than 30 ng/J (0.07 lb/10^6 Btu).

The results of the 30-day test are summarized in the following table. This Table (4-6) presents baseline NO, NO at 4 percent O_2 and at 2 percent O_2 operating levels and the overall NO level for the entire period. Also tabulated is the percentage reduction from the baseline condition for each operating condition.

4.3 CONCLUSIONS FROM THE 30-DAY TEST

The 30-day test proved that the combustion modifications employed on this process heater were effective NO_x control techniques. Staged combustion air resulted in a 60 percent reduction in NO emission rate with the heater operating at 4 percent oxygen in the stack and 71 percent reduction when the stack oxygen was lowered to 2 percent. Even when the heater was operated at high O_2 levels, the NO emission rate was lower than baseline.

Operation of the heater with staged combustion air and normal excess air did not require any additional operating personnel or attention. No changes in heat flux distribution were observed. Post-test examination of the staged air lances showed no discernible deterioration. Some discoloration of the stainless steel was evident.

The continuous monitor system provided accurate, reliable data for the entire test period. The monitor system was in service 735.5 hours out of a possible 769 hours for a 96 percent availability.

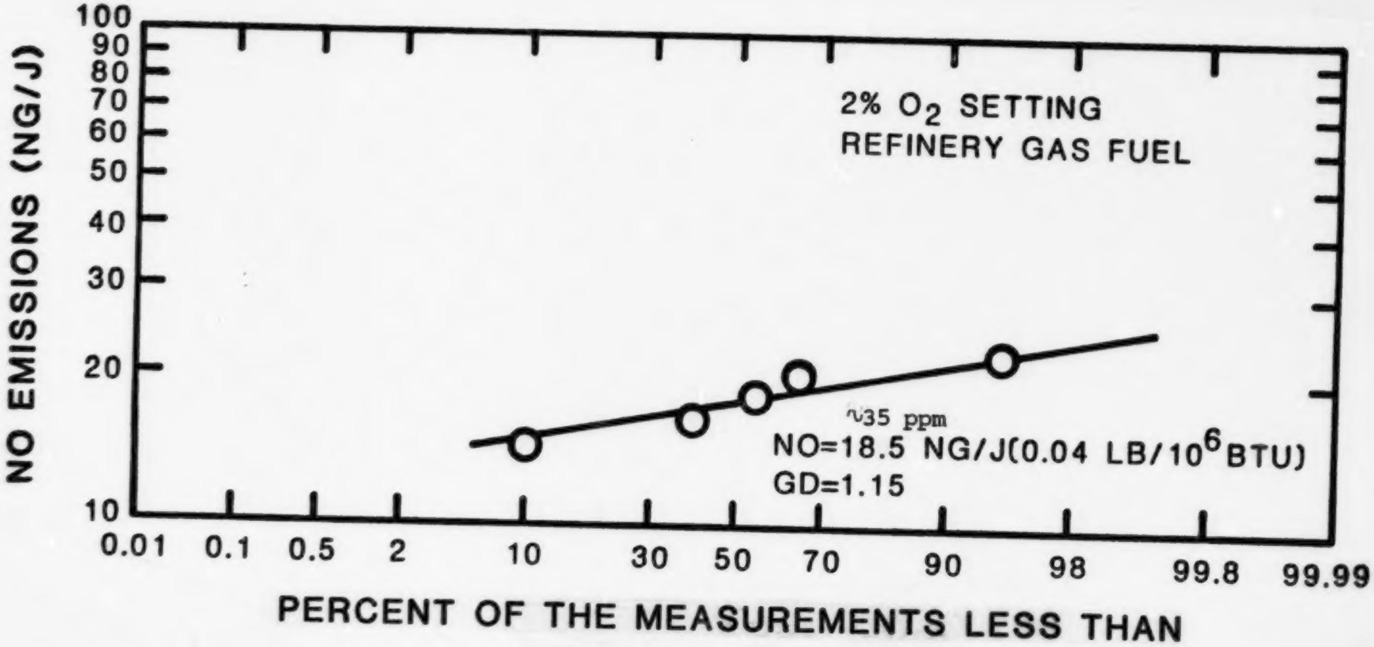

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Figure 4-8. Log probability curve of NO emissions from a petroleum process heater at 2 percent O_2.

+ 2% O_2

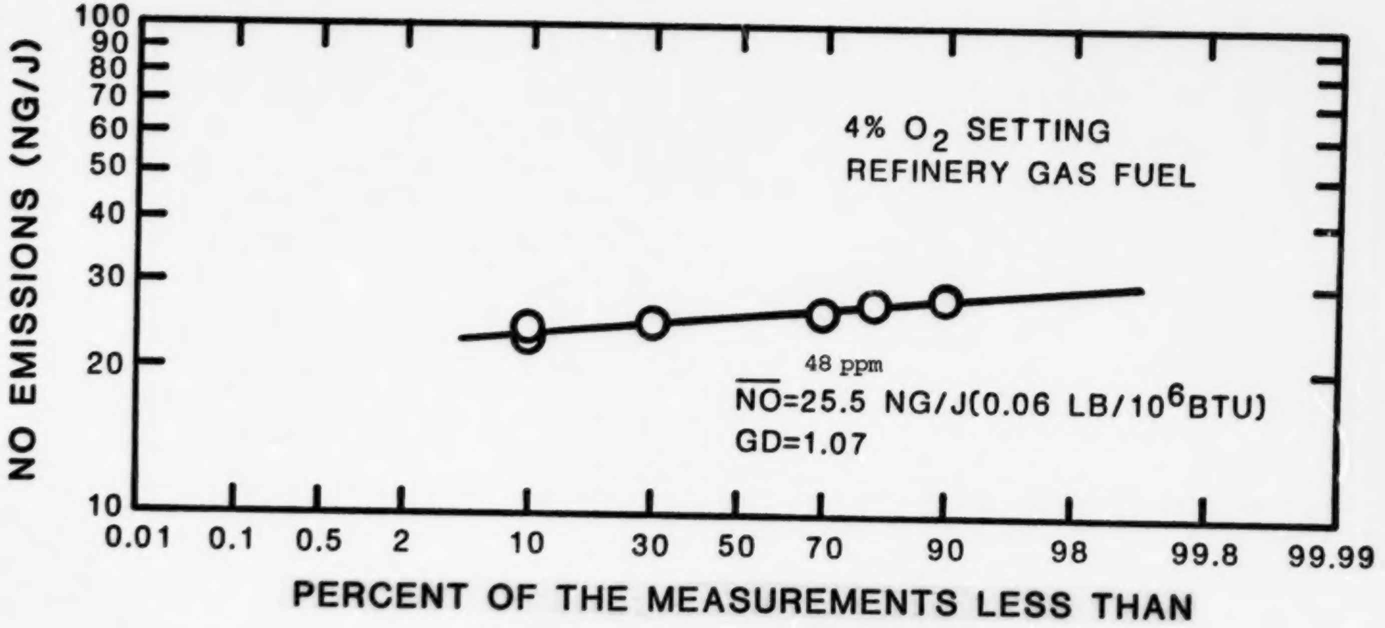

Figure 4-9. Log probability curve of NO emissions from a petroleum process heater at 4 percent O_2.

TABLE 4-6. SUMMARY OF 30-DAY TEST RESULTS FOR NO_x REDUCTIONS BELOW BASELINE FOR A PROCESS HEATER WITH STAGED COMBUSTION AIR

	Baseline NO_x	SCA at 4% O_2	SCA + LEA (2% O_2)	NO_x overall (Average over 30 days)
ppm at 3% O_2	125	49	35	43
ng/J	66	25.8	18.5	22.5
$lb/10^6$ Btu	0.15	0.06	0.04	0.05
% Reduction from Baseline	--	60	71	64

SECTION 5.0

DISCUSSION OF RESULTS

5.1 NO_x EMISSION REDUCTION POTENTIAL OF COMBUSTION MODIFICATIONS

Comparing the results shown in Table 3-1 with those shown in Table 4-5, one observes that greater NO_x emission reductions occurred during the long-term test (firing gas fuel) than occurred during the short-term tests of the staged combustion air system firing the same fuel. This was due in part to the fact that the baseline NO_x emissions were higher for the long-term test than they had been for the parametric tests (66 ng/J versus 54 ng/J). In addition, the modified NO_x emissions both at 4 percent O_2 and at 2 percent O_2 were lower during the long-term tests than they had been during the parametric tests (25.8 ng/J at 4 percent O_2 and 18.5 ng/J at 2 percent O_2 for the long-term test, as opposed to 35 ng/J at 4 percent O_2 and 26 ng/J at 2 percent O_2 for the short-term tests).

The most likely explanation for the higher observed baseline emissions during the 30-day test of the process heater was that the heater was operating at a higher crude feed rate (70.9 m^3/h compared with 63.6 m^3/h during the parametric tests). The lower modified emission levels attained during the long-term tests may be attributed to the lower burner stoichiometric ratios achievable with the larger fan. Recall that the larger fan was installed prior to the 30-day test in order to enhance NO_x emission reductions firing gas/oil fuels. Thus, the staged air capability was somewhat greater for the long-term tests firing gas fuel than it had been for the short-term tests firing the same fuel. At 2 percent stack O_2, $\Phi_B = 0.60$ could be attained and at 4 percent O_2, $\Phi_B = 0.70$ for the long-term gas-firing test. However, during the short-term gas-firing tests at 2 percent stack O_2, Φ_B equalled 0.65 and at 4 percent O_2, Φ_B equalled 0.74.

Based on the foregoing discussion it appears reasonable to accept the long-term test results as representative of actual NO_x reductions which may be achieved by means of staged combustion air firing gaseous fuel.

For the gas/oil mixed fuel the results shown in Table 3-1 are the best indications of the staged air system performance relative to NO_x reduction potential since no long-term tests have been conducted firing both fuels simultaneously.

For both gaseous fuel and gas/oil firing NO_x emission reduction results are reported relative to a 4 percent stack O_2 baseline condition and also relative to emission levels at 2 percent stack O_2. It is believed that 4 percent stack O_2 is obtainable without heater modifications and without additional operator training. However, there may be a cost associated with lowering the stack oxygen content from 4 percent to 2 percent. This cost is incurred because of additional controllers and/or oxygen sensors required to control the heater automatically at such low excess air levels and thus prevent smoking and possible flooding of the heater. Possible methods of controlling excess air in the natural draft heater are discussed in a later section.

The maximum NO_x reduction potential was achieved when both lowered excess air and staged combustion air were applied in combination. For gas fuel (from the 30-day test results) this amounted to a 71 percent reduction from baseline and for the gas/oil combination fuel the reduction was 53 percent below baseline.

The NO_x reduction potential firing gas fuel was practically nil when steam injection through the oil gun was applied. Although a small NO_x reduction was observed when steam injection was applied at 3 percent O_2, no reduction was observed when the modification was attempted at 2 percent stack O_2.

5.2 EFFICIENCY IMPLICATIONS

The efficiency implications of the steam injection and staged combustion air modifications are shown in Table 3-1.

Steam injection resulted in a decrease in heater thermal efficiency. The increased fuel consumption required to offset this drop in efficiency was calculated to be about 2 percent of the baseline fuel consumption rate.

Staged combustion air applied alone and in combination with lowered excess air resulted in thermal efficiency increases in every case. When applied at 4 percent stack O_2, a small efficiency gain was observed for gas fuel (corresponding to a 0.2 percent decrease in fuel consumption) and a slightly larger gain was observed for the No. 6 oil/gas combined fuel (corresponding to a 0.6 percent decrease in fuel consumption).

Lowering stack O_2 from 4 percent to 2 percent produced an efficiency increase corresponding to about a 3 percent reduction in fuel consumption firing either gas or gas/oil fuel.

Application of staged combustion air at 2 percent stack O_2 further decreased fuel consumption below the level attained by merely lowering excess air. A 0.3 percent decrease in fuel consumption below that at 2 percent O_2 without staged air was observed for gas fuel and a 1.9 percent decrease was found for the gas/oil fuel. The change in fuel consumption relative to baseline when SCA and LEA were applied in combination were -3.1 percent firing gas and -4.8 percent firing No. 6 oil and gas.

5.3 METHODS FOR DECREASING EXCESS AIR ON NATURAL DRAFT PROCESS HEATERS

There are two fundamentally different ways of controlling the excess air in naturally drafted process heaters which are now commercially available, although heretofore not in widespread use because of cost considerations. They are:

1. Oxygen-sensing automatic feedback/control systems
2. Automatic furnace draft controllers

The oxygen-sensing automatic feedback/control system uses the signal from a flue gas oxygen analyzer to control the stack damper position thereby altering the furnace draft until the desired stack gas O_2 content is obtained.

The automatic furnace draft controller adjusts the stack draft which indirectly controls the combustion air flow into the heater (and, thus, the stack O_2 concentration). It does so mechanically by means of a set of two counterweighted dampers which are adjusted to allow ambient air to leak into the stack (which is always at a negative pressure). In this way, the furnace draft is automatically adjusted as the fuel flow (i.e. load) changes to maintain a roughly constant excess air level. It should be emphasized that this latter technique may have limitations in load following and precise O_2 level control.

5.4 APPLICABILITY OF THE STAGED COMBUSTION AIR TECHNIQUE

The combustion modification technique of staged combustion air has now been demonstrated on a full-scale vertically fired natural draft process heater for thirty days firing refinery gas. The modification has been applied for short-term tests (up to 12 hours) on this unit when firing No. 6 oil and refinery gas in approximately equal proportions by heat input.

Ultimately it is expected that this modification could be applied to virtually any type of process heater, however the fan requirement, the NO_x reduction potential, and the efficiency implications are all likely to be site specific. This is true because of the wide variety in heater designs currently in use. Temperature and pressure/draft profiles may differ significantly from those measured at the present site and may have significant effects on the NO_x reduction potential and efficiency impact of staged combustion air.

For heaters which are mechanically drafted, this combustion modification technique may prove to be very cost effective since a separate staged air fan would probably not be required. The initial design and installation of a staged air system would likely be more complex for that type heater, however, than they were for the natural draft unit.

A horizontally fired heater would probably require that lances be placed horizontally into the firebox. In that case lance skin temperatures would become more critical since they may be high enough to cause the lances to droop. Some vertically fired heaters may be more easily modified by means of horizontal lances due to ground clearance limitations (the distance between the heater floor and the ground limits the staged air lance height above the burner). In that instance the modification is similar to overfire air or "NO_x ports" which are already in use on many industrial and utility boilers.

It is expected that staged combustion air will be applicable to all process heaters regardless of fuel type although optimum lance placement and orientation may be different when burning 100 percent No. 6 fuel oil from the configuration used for refinery gas fuel and the gas/oil mixture.

In any situation where key parameters are different from those of the present test unit (e.g., fuel type, pressures, temperatures, air velocities, and mixing patterns) this staged combustion air system performance may differ from the present performance with regard to NO_x emission reductions and efficiency impact.

One must also consider that the present test unit was a crude oil heater. This type of furnace typically is one of the most flexible in a refinery in terms of tolerating changes in temperature and heat flux distributions. Other units such as reforming heaters, vacuum heaters and the like often have process fluids of more than a single phase or operate at a higher temperature regime where the process fluid flow may be seriously affected by variations from a design heat flux distribution. These process limitations should be studied before attempting to apply the staged air modification to a process heater used for any such complex application.

There is remarkable agreement between the pilot scale and full scale NO_x emissions and emission reductions due to combustion modification. Baseline NO_x levels firing gaseous fuel ranged from 54.6 to 67.0 ng/J for the pilot heater and from 50 to 66 ng/J on the full scale unit. The maximum reductions in NO_x emissions firing gas fuel were 46 percent below baseline at normal operating stack O_2 and 67 percent at reduced O_2 for the pilot heater. For the full scale heater these reductions were 60 percent for normal O_2 and 71 percent for reduced O_2. In terms of absolute emission levels achieved by SCA the numbers are also in reasonable agreement - 29.4 ng/J (pilot scale) versus 25.5 ng/J (full scale) at normal O_2 and 18.0 ng/J (pilot scale) versus 18.5 ng/J (full scale) at reduced O_2.

Firing 100 percent No. 6 oil fuel on the subscale heater produced an average 150 ng/J of NO_x as opposed to about 155 ng/J in the present tests with a 50/50 oil-gas mix. The percent reductions in NO_x emissions attained with SCA, however, were very nearly the same in both cases - 35 percent (pilot scale) and 34 percent (full scale) at normal O_2 and 51 percent (pilot scale) versus 53 percent (full scale) at reduced O_2.

The agreement between subscale and full scale tests suggests two observations:

1. The NO_x reductions for 100 percent residual oil firing with a staged combustion air modification should be reasonably close to those predicted by the subscale tests (i.e., roughly 35 percent below baseline when applied at 3-4 percent stack O_2 and about 50 percent below baseline at 1-2 percent O_2).

2. Pilot scale testing of combustion modifications is a valid technique for predicting full scale performance when conducted under properly controlled conditions and with proper attention to key parameters.

SECTION 6.0

COST ANALYSIS OF STAGED COMBUSTION AIR APPLIED TO A NATURAL DRAFT PROCESS HEATER

6.1 LIMITATIONS OF THE ANALYSIS

The costs and NO_x reductions discussed in this section pertain to a permanent installation of staged combustion air lances on a natural draft process heater firing either all gaseous fuel or a 50/50 mixture of residual oil and gas (by heat input rate).

Costs are given in November, 1981 dollars and represent KVB's best estimate of material and labor costs. They do not represent actual costs for any particular system.

NO_x reduction potentials are those obtained (a) during a long-term (30-day) test for gaseous fuel and (b) during short-term parametric tests for the combination oil/gas fuel.

6.2 INITIAL FIXED COSTS

The initial fixed costs of a permanent staged combustion air lance system are given in Table 6-1. They apply to a system schematic essentially the same as that shown in Figure 2-3 except that all of the pipe and fittings are now schedule 40 carbon steel. This is dictated by plant safety standards. The ball valves controlling air flow to each set of four lances have also been eliminated since the air distribution is nearly equal to each burner without the use of any flow control valves. Equal air distribution to each burner provided the best NO_x reduction capability during the parametric tests so it has been the guiding principle behind the permanent system design. In addition the blower size has been optimized. The permanent design uses a 2.08 m^3/s (4400 scfm) blower with a discharge pressure of 14 kPa (2 psi) and it is driven by a 44.8 kW (60 hp) electric motor.

TABLE 6-1. INITIAL FIXED COSTS OF A PERMANENT STAGED COMBUSTION AIR SYSTEM FOR A NATURAL DRAFT PROCESS HEATER RATED AT 16.1 MW THERMAL INPUT

Item	Cost (November 1981 $) Labor To Install	 Material	 Labor + Material
1. Civil and Structural (Foundations)	900	300	1,200
2. Blower, Motor, and Outlet Adapter	900	6,200	7,100
3. Pipe and Fittings, Lances, Installation of Couplings in Heater Floor	8,800	6,740	15,540
4. Instrumentation	50	250	300
5. Electrical (including starter for motor)	3,600	4,470	8,070
6. Engineering	8,000	300	8,300
7. Construction	4,000	2,200	6,200
8. Indirect (including taxes, contingency, etc.)	--	3,000	3,000
TOTALS	$26,250	$23,460	$49,710

The costs determined here are significantly higher than those determined in 1980 for the all-polyvinyl chloride system which was used in the field experiments. The initial fixed cost for the test system was reported in Ref. 3 to be $30,785 in 1980 dollars. Thus, even adjusted for about 12 percent annual inflation the permanent system cost is expected to be nearly 1-1/2 times the cost of the test system.

This large difference in cost between the test and the permanent system is due primarily to a large difference in the cost of the pipe and fittings for the two different materials, PVC and carbon steel. The difference in installation and construction costs is also considerable.

In order to realize the full NO_x reduction potential and efficiency enhancement capability of the staged combustion air (SCA) system it is necessary to reduce the stack oxygen content from a normal operating level (4 percent O_2) to an optimum low level (2 percent O_2). KVB discovered during the long-term test of the SCA system while firing refinery gas that operation at 2 percent stack oxygen dictates the installation of an automatic O_2 or stack draft controller.

According to a source at the plant where one demonstration unit has been retrofitted on a process heater, the installed costs of an automatic draft controller (applicable only to natural draft heaters) are expected to be about $40,000 (Ref. 4) for a heater of the same size as the present test unit.

From Refs. 2 and 4 the initial costs for both the staged air system and the automatic draft controller may be conservatively estimated to scale with heater size (heat input rate) to the 2/3 power for both the staged air system and the automatic draft controller.

6.3 ANNUAL OPERATING AND MAINTENANCE COSTS

For the application of staged combustion air only, one must consider the annual blower electricity costs, the annual maintenance costs on the blower and staged air lances, and the annual fuel savings resulting from the efficiency increases due to the addition of the SCA system.

In order to reduce stack oxygen from the normal operating level (4 percent O_2) to an optimum low level (2 percent O_2) one must consider maintenance costs of an automatic air control system as well as the fuel savings which result from the lowered stack losses. According to Ref. 4 the costs are expected to be minimal - only about \$200/year.

The costs of operating the staged air blower in the permanent design system may be determined assuming that the blower motor will operate at design capacity (i.e., 45 kW) and assuming a use factor for the heater of 0.70 (to account for normal down time on the heater as well as normal operating heat input rate relative to design capacity). We will also assume an electrical-to-mechanical conversion efficiency in the motor of 85 percent. The calculation proceeds as follows using the test plant's electrical energy cost of 5.5¢/kW-h:

Annual Blower Electrical Energy cost

$$= 45 \text{ kW} \times 0.70 \times \frac{1}{0.85} \times 8760 \frac{\text{h}}{\text{y}} \times \frac{\$0.055}{\text{kW-h}}$$

$$= \$17,855$$

This cost will change slightly with changes in operating conditions such as excess air level, however the magnitude of the change will be small compared to the total cost.

In the absence of more detailed information the staged air system annual maintenance costs are assumed to be 3 percent of the initial fixed costs. This amounts to \$1500 per year. This is typical for refineries (Ref. 5).

The fuel savings which result from the application of staged combustion air at 4 percent stack O_2, the savings due to the use of lowered excess air only, and due to the use of SCA and LEA combined were shown in Table 3-1. These values may be converted into cost savings using the plant's gas fuel cost of \$3.44/10^6 Btu or \$0.01174/kW-h and the heater use factor of 0.70. These values are shown in Table 6-2. The values are calculated from the decreases in fuel consumption which occurred firing gas fuel only since those are more conservative than the fuel savings associated with the firing of No. 6 oil and gas. The annual unmodified fuel consumption is thus determined:

$$16{,}115 \text{ kW} \times 8760 \frac{\text{h}}{\text{y}} \times 0.70 = 98.82 \cdot 10^6 \text{ kW-h/y}$$

The cost of this fuel is thus:

$$98.82 \cdot 10^6 \frac{\text{kW-h}}{\text{y}} \times \frac{\$0.01174}{\text{kW-h}} = \$1{,}160{,}000/\text{y}$$

TABLE 6-2. FUEL SAVINGS (NOV., 1981 $) DUE TO COMBUSTION MODIFICATIONS TO A NATURAL DRAFT PROCESS HEATER RATED AT 16.1 MW THERMAL INPUT

Modification	Percent Decrease in Fuel Consumption	Savings ($)
1. Staged Combustion Air (SCA) at 4% O_2	0.2	2,320
2. Lowered Excess Air (LEA)	2.8	32,485
3. SCA + LEA	3.1	35,965

The percent decrease in fuel consumption for combined gas/No. 6 oil firing is shown in Table 3-1 to be 0.6 percent for staged air at 4 percent O_2, 3.0 percent for lowered excess air, and 4.8 percent for the combination of those two modifications. Using the fact that the plant's fuel oil costs are nearly equal to the plant gas costs, the annual savings in dollars may be calculated for the three modifications above. The results of these calculations give a savings of $6961 for staged air at 4 percent O_2, $34,806 for lowered excess air, and $55,690 for the combination modification.

The annual fuel savings of any of the above modifications will be roughly proportional to heater size (in heat input). The blower electrical cost associated with modifications 1 and 3 will also rise linearly with unit heat input rate since the heat in is proportional to the total volume of combustion air with small variations due to different fuel compositions. Since a constant burner stoichiometric ratio is desired for any unit, the volume of staged air flow, Q, is a fixed percentage of the total flow for any size heater (in this analysis the staged air flow represents about 40 percent of the total combustion air flow at 4 percent stack O_2 and about 50 percent of the total air flow at 2 percent stack O_2). Also, the power required to drive the blower is directly proportional to the volumetric flow rate of air, Q, through the blower. The annual maintenance costs for both staged air and the automatic draft controller are expected to increase with heater size to the 2/3 power, since they are a fixed percentage of the initial costs.

To summarize the preceding relationships:

1) Initial Fixed Costs (IFC) $\propto MW^{2/3}$,

2) Annual Maintenance Costs = 0.03 x IFC, thus

3) Annual Maintenance Cost $\propto MW^{2/3}$,

4) Annual Fuel Savings $\propto MW^1$, and

5) Annual Blower Electricity Costs $\propto MW^1$.

For a natural draft heater rated at 16.1 MW thermal input the annual costs of combustion modifications are given in Table 6-3. Values in parentheses represent a savings.

TABLE 6-3. ANNUAL OPERATING COSTS (NOV., 1981 $) OF COMBUSTION MODIFICATIONS TO A NATURAL DRAFT PROCESS HEATER RATED AT 16.1 MW THERMAL INPUT

Item	SCA* Only (4% O_2)	LEA* Only (4% O_2 → 2% O_2)	SCA + LEA*
Blower Electricity	17,855	0	17,855
Maintenance	1,500	200	1,500
(Fuel Savings)	(2,320)	(32,485)	(35,965)
Totals, costs (savings)	17,035	(32,285)	(16,610)

*SCA = Staged Combustion Air
LEA = Lowered Excess Air

6.4 TOTAL ANNUALIZED COSTS

The assumptions made in determining the total annualized costs for a 16.1 MW_{th} natural draft process heater are given in Table 6-4. These assumptions are explained in detail in Ref. 5 and will not be discussed here.

The total annualized costs are calculated by adding the annual costs including taxes and insurance to the annualized capital costs. These costs are presented in Table 6-5 for the following modifications applied to a 16.1 MW_{th} process heater: SCA at 4 percent O_2, LEA only, and the combination of SCA plus LEA.

To a first approximation the total annualized cost of SCA applied at 4 percent O_2 may be related to the heat input rate of the heater by using the cost scaling factors presented in Section 6.3. Calculations of total annualized costs (savings) for staged air applied at 4 percent O_2 , lowered excess air only, and staged air plus lowered excess air are shown for heater sizes of 29.3 MW (100 x 10^6 Btu/h) and 147 MW (500 x 10^6 Btu/h) in Tables 6-6 and 6-7.

The costs for SCA at 4 percent O_2 are plotted versus heat input rate in Figure 6-1. From that log-log plot one may determine an approximate power law for the total annualized costs. The slope of the curve shown in Figure 6-1, is approximately 0.86. Thus,

$$\frac{\text{Cost at Size 1}}{\text{Cost at Size 2}} = \left(\frac{MW_1}{MW_2}\right)^{0.86}$$

This is valid for heat input rates between 3 MW and 147 MW.

Of course, one observes from Tables 6-5, 6-6, and 6-7 that lowered excess air gives increasing savings as heater size increases. It will clearly be advantageous to apply this modification from the standpoint of economics alone.

For the combination of staged air and lowered excess air, however, an interesting situation develops. The total annualized costs rise for heaters less than 29.3 MW thermal input but than fall off for still larger heaters

TABLE 6-4. ASSUMPTIONS MADE IN DETERMINING TOTAL ANNUALIZED COSTS

1. State and Federal Property Taxes = 11% of Initial Capital Cost
2. Insurance Charges = 0.5% of Initial Capital Cost
3. Straight-Line Depreciation Over 12 Years
4. State and Federal Income Taxes = 50%
5. Investment Tax Credit (First Year Only) = 10%
6. 100% Equity Financing (Debt/Equity = 0)
7. 15% Rate of Return
8. Capital Recovery Factor = 0.2773

TABLE 6-5. TOTAL ANNUALIZED COSTS OF COMBUSTION MODIFICATIONS ON A 16.1 MW_{th} NATURAL DRAFT PROCESS HEATER

Item	Costs (November 1981 $)		
	SCA* @ 4% O_2	LEA* Only	SCA + LEA
Annual Operating Cost (Savings)	17,035	(32,285)	(16,610)
State and Federal Taxes (11% of IFC)*	5,468	4,400	9,868
Insurance (0.5% of IFC)*	249	200	449
Subtotal, costs (savings)	22,752	(27,685)	(6,293)
Initial Fixed Costs	49,710	40,000	89,710
Annual Capital Charge	13,785	11,092	24,877
Total Annualized Costs (savings)	36,537	(16,593)	18,585

*SCA = Staged Combustion Air

LEA = Lowered Excess Air

IFC = Initial Fixed Costs

TABLE 6-6. TOTAL ANNUALIZED COSTS OF COMBUSTION MODIFICATIONS ON A 29.3 MW_{th} NATURAL DRAFT PROCESS HEATER

Item	Costs (November 1981 $)		
	SCA* @ 4% O_2	LEA* Only	SCA + LEA
Annual Operating Cost (Savings)	30,508	(58,821)	(30,722)
State and Federal Taxes (11% of IFC)*	8,151	6,559	14,709
Insurance (0.5% of IFC)*	370	298	669
Subtotal, costs (savings)	39,029	(51,964)	(15,344)
Initial Fixed Costs	74,098	59,624	133,722
Annual Capital Charge	20,547	16,534	37,081
Total Annualized Costs (savings)	59,576	(35,430)	21,737

*SCA = Staged Combustion Air

LEA = Lowered Excess Air

IFC = Initial Fixed Costs

TABLE 6-7. TOTAL ANNUALIZED COSTS OF COMBUSTION MODIFICATIONS ON A 147 MW_{th} NATURAL DRAFT PROCESS HEATER

Item	Costs (November 1981 $)		
	SCA* @ 4% O_2	LEA* Only	SCA + LEA
Annual Operating Cost (Savings)	159,442	(295,728)	(158,799)
State and Federal Taxes (11% of IFC)*	23,887	19,221	43,108
Insurance (0.5% of IFC)*	1,086	874	1,959
Subtotal, costs (savings)	184,415	(275,633)	(113,732)
Initial Fixed Costs	217,156	174,738	391,894
Annual Capital Charge	60,217	48,455	108,672
Total Annualized Costs (savings)	244,632	(227,178)	(5,060)

*SCA = Staged Combustion Air

LEA = Lowered Excess Air

IFC = Initial Fixed Costs

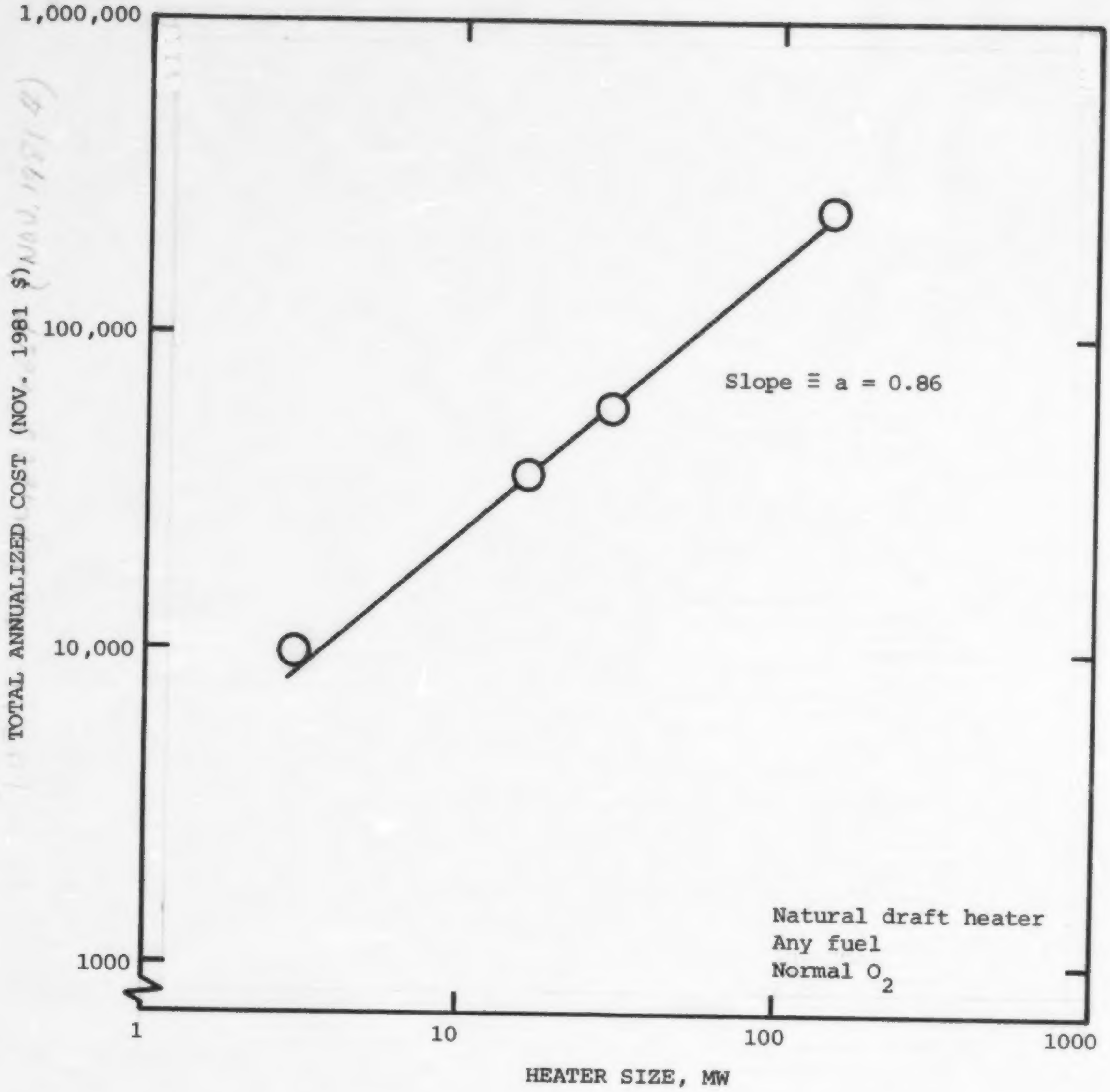

Figure 6-1. Total annualized costs as a function of design heat input capacity for natural draft process heaters with staged combustion air at normal stack oxygen.

until at the 147 MW_{th} size, a savings is actually realized. This indicates that for very large heaters, plants can actually consider the combination modification a capital investment rather than strictly a capital expense item as would be the case for the staged air modification without the addition of lowered excess air. This is true regardless of NO_x reduction capability of the modifications.

6.5 COST/EFFECTIVENESS RATIO

The cost/effectiveness ratio of staged combustion air applied at 4 percent O_2 and of the combined SCA/LEA modification is determined here. The cost/effectiveness ratio, CE, is defined as the total annualized costs divided by the annual NO_x reduction potential to give a dollar amount per metric ton of NO_x removed by the modification.*

The annual NO_x reduction potential is given for three heater sizes in Table 6-8.

These calculations assume a NO_x reduction capability of 39 ng/J for the staged combustion air system and apply to both gaseous fuel and to the 50/50 mixture of gas and No. 6 oil fuel. This number is the difference between the unmodified NO_x emission and the emission rate with SCA applied at 4 percent O_2. By once again assuming a use factor of 0.70 for the heater the calculation of NO_x emission reduction potential at the 16.1 MW size proceeds as follows:

NO_x Reduction Potential

$$= 16.1 \times 10^6 \frac{J}{s} \times 0.70 \times 8760 \frac{h}{y} \times 3600 \frac{s}{h} \times 39 \times 10^{-15} \frac{Mg}{J}$$

$$= 13.86 \frac{Mg}{Y}$$

---

*A lower value of cost/effectiveness ratio indicates a lower cost and/or greater NO_x reduction.

TABLE 6-8. ANNUAL NO_x REDUCTION POTENTIAL (Mg) OF COMBUSTION MODIFICATIONS AT THREE HEATER SIZES

Modification*	Heater Size		
	16.1 MW	29.3 MW	147 MW
SCA at 4% O_2	13.86	25.22	126.5
SCA + LEA	17.06	31.05	155.8
LEA only (gas fuel)	2.84	5.17	47.2
LEA only (gas + No. 6 oil)	11.37	20.69	103.8

*SCA = Staged Combustion Air

LEA = Lowered Excess Air

It is expected that the change in emission factor due to combustion modification will hold approximately for all heater sizes so that the NO_x reduction potential will scale linearly with heat input rate.

For the combination of staged air and lowered excess air the NO_x reduction potential is assumed to be 48 ng/J which was the value for gas firing. This is conservative relative to the value for gas/oil firing which was 60 ng/J.

For lowered excess air alone the NO_x reduction potential differed for the gaseous fuel and for the combination fuel. The reduction in NO_x emission factor firing gas was only 8 ng/J whereas it was 32 ng/J firing oil and gas. The two results are shown separately in Table 6-8.

The cost/effectiveness ratio of combustion modifications applied to three heater sizes is shown in Table 6-9. The values for LEA and for SCA plus LEA modification on the largest heater are negative indicating a savings in combination with a NO_x reduction. This is a desirable situation, however, one must realize that a modification which saves money yet produces only a small NO_x reduction will have a large negative cost/effectiveness ratio. This may not be the most desirable modification if the level of NO_x reduction is lower than is necessary to achieve compliance with regulations or to offset future emissions from plant expansions.

The cost and cost/effectiveness ratio of staged combustion is compared with that of other commercially available modifications in Table 6-10 for a 29.3 MW (100 x 10^6 Btu/h) natural draft process heater. The values for low-NO_x burners and for selective non-catalytic reduction are developed from Ref. 6. The values for cost/effectiveness ratio from Ref. 6 have been adjusted to include state and federal taxes and a capital annualization factor of 0.2773. Fuel penalties were already included where efficiencies were reduced by modifications discussed in Ref. 6, however, no credit was taken in Ref. 6 for fuel savings where efficiencies increased due to a modification. Thus, the usual fuel savings due to installation of low-NO_x burners (since they often operate at lower excess air than standard burners) is not accounted for in Table 6-10. Note also that the column "Annual Operating Costs (Savings)" does not include taxes or insurance, however these items are accounted for in the cost/effectiveness ratio column.

TABLE 6-9. COST/EFFECTIVENESS RATIO ($/Mg) OF COMBUSTION MODIFICATIONS APPLIED TO THREE NATURAL DRAFT PROCESS HEATER SIZES

Modification	Heater Size		
	16.1 MW	29.3 MW	147 MW
Staged Combustion Air at 4% O_2	2636	2362	1934
Staged Combustion Air + Lowered Excess Air	1089	700	(40)*
Lowered Excess Air Firing Gas	(5843)*	(6853)*	(4813)*
Lowered Excess Air Firing Oil and Gas	(1459)*	(1712)*	(2189)*

*Savings

TABLE 6-10. COST OF VARIOUS CONTROL TECHNOLOGIES APPLIED TO A 29.3 MW NATURAL DRAFT PROCESS HEATER

Type of Control	Approximate Percent NO_x Reduction	Installed Capital Cost $/MW	Annual Operating Costs (Savings) $/Year	Average Cost/ Effectiveness Ratio $/Mg	$/lb
Lowered Excess Air (gas fuel)	15	2,035	(58,821)	(6,853)	(3.11)
Low-NO_x Burners	35	2,915	--	2,599	1.18
Selective Noncatalytic Reduction	50	4,266	46,089	5,176	2.35
Staged Combustion Air, Normal O_2 (gas fuel)	60	2,529	30,508	2,362	1.07
Staged Combustion Air, Low O_2 (gas fuel)	71	4,563	(30,722)	700	0.32

From Table 6-10, one observes that for a natual draft heater firing gas fuel both the percent NO_x reduction and the cost effectiveness of staged combustion compare favorably to other commercially available combustion modification techniques. Lowered excess air is certainly the most desirable modification from a financial standpoint, however it offers the least NO_x reduction capability. For oil-fired heaters, however, the NO_x reduction capability of LEA may approach both low-NO_x burners and staged combustion lances (applied at normal O_2).

The costs of a staged combustion air system on a natural draft heater may be looked at in another way. The additional cost of NO_x control per barrel of oil produced may be calculated for the present test heater as follows:

$$\frac{\Delta \text{Cost}}{\text{Unit of Throughput}} = \frac{\text{Total annualized cost of } NO_x \text{ control}}{\text{Annual Crude Throughput}}.$$

For the present heater this works out to 5.5¢/m^3 (0.9¢/bbl) for SCA applied at 4 percent O_2. Even if this modification were applied at several steps in the oil production process, the maximum increase in oil production costs may be seen to be minimal. Compared to the initial cost of the crude, the total NO_x cost of NO_x reduction would probably be less than 0.2 percent.

SECTION 7.0

REFERENCES

1. Hunter, S. C. et al., "Application of Combustion Modifications to Industrial Combustion Equipment," EPA-600/7-79-015a, NTIS No. PB 294 214, January 1979.

2. Hunter, S. C. et al., "Application of Advanced Combustion Modifications to Industrial Process Equipment: Subscale Test Results," final report for EPA Contract No. 68-02-2645.

3. Tidona, R. J. and Carter, W. A., "Field Testing of Staged Combustion on a Petroleum Process Heater," prepared for the American Flame Research Committee 1980 Fall Meeting, Paper No. P-263, October 27-28, 1980.

4. Private communication from Gary D. Davis, Tosco Corporation, November 24, 1981.

5. Cherry, S. S. and Hunter, S. C., "Cost and Cost Effectiveness of NO_x Control in Petroleum Industry Operations," American Petroleum Institute Publication No. 4331, October 1980.

6. South Coast Air Quality Management District and Stationary Source Control Division, Air Resources Board, Joint Staff Report, SS-81-016, "Public Meeting to Consider a Suggested Control Measure for the Control of Emissions of Oxides of Nitrogen from Boilers and Process Heaters in Refineries," October 1981.

SECTION 8.0

CONVERSION FACTORS

SI Units to Metric or English Units

To Obtain	From	Multiply By
g/Mcal	ng/J	0.004186
10^6 Btu	GJ	0.948
Btu	gm cal	3.9685×10^{-3}
lb/10^6 Btu	ng/J	0.00233
ft	m	3.281
in.	cm	0.3937
ft^2	m^2	10.764
ft^3	m^3	35.314
lb	kg	2.205
Fahrenheit	Celsius	$t_F = 9/5(t_c) + 32$
Fahrenheit	Kelvin	$t_F = 1.8t_K - 460$
psig	Pa	$P_{psig} = (P_{pa})(1.450 \times 10^{-4}) - 14.7$
psia	Pa	$P_{psia} = (P_{pa})(1.450 \times 10^{-4})$
iwg (39.2 °F)	Pa	$P_{iwg} = (P_{pa})(4.014 \times 10^{-3})$
10^6 Btu/hr	MW	3.413
GJ/hr	MW	3.60

To Obtain ppm at 3% O_2 of	Multiply* Concentration in ng/J by
Natural Gas Fuel	
CO	3.23
HC	5.65
NO or NO_x	1.96
SO_2 or SO_x	1.41
Oil Fuel	
CO	2.93
HC	5.13
NO or NO_x	1.78
SO_2 or SO_x	1.28
Coal Fuel	
CO	2.69
HC	4.69
NO or NO_x	1.64
SO_2 or SO_x	1.18

*These conversions depend on fuel composition.
The values given are for typical fuels.

English and Metric Units to SI Units

To Obtain	From	Multiply By
ng/J	lb/10^6 Btu	430
ng/J	g/Mcal	239
GJ	10^6 Btu	1.055
m	ft	0.3048
cm	in.	2.54
m^2	ft^2	0.0929
m^3	ft^3	0.02832
kg	lb	0.4536
Celsius	Fahrenheit	$t_c = 5/9\ (t_F - 32)$
Kelvin	Fahrenheit	$t_K = 5/9\ (t_F - 32) + 273$
Pa	psig	$P_{pa} = (P_{psig} + 14.7)(6.895x10^3)$
Pa	psia	$P_{pa} = (P_{psia})(6.895x10^3)$
Pa	iwg (39.2 °F)	$P_{pa} = (P_{iwg})(249.1)$
MW	10^6 Btu/hr	0.293
MW	GJ/hr	0.278

To Obtain ng/J of	Multiply* Concentration in ppm @ 3% O_2 by
Natural Gas Fuel	
CO	0.310
HC	0.177
NO or NO_x (as NO_2)	0.510
SO_2 or SO_x	0.709
Oil Fuel	
CO	0.341
HC	0.195
NO or NO_x (as NO_2)	0.561
SO_2 or SO_x	0.780
Coal Fuel	
CO	0.372
HC	0.213
NO or NO_x (as NO_2)	0.611
SO_2 or SO_x	0.850

*These conversions depend on fuel composition. The values given are for typical fuels.

APPENDIX A-1.0

GASEOUS AND PARTICULATE EMISSIONS TEST METHODS AND INSTRUMENTATION

All emission measurement instrumentation was carried in a 9.8 m x 2.4 m (8 x 42 ft) mobile laboratory trailer. A plan view of the trailer is shown in Figure A-1. The gaseous species measurements were made with analyzers located in the trailer.

The emission measurement instrumentation used was the following:

TABLE A-1. EMISSION MEASUREMENT INSTRUMENTATION

Species	Manufacturer	Measurement Method	Model No.
Hydrocarbon	Beckman Instruments	Flame Ionization	402
Carbon Monoxide	Beckman Instruments	IR Spectrometer	865
Oxygen	Teledyne	Polarographic	326A
Carbon Dioxide	Beckman Instruments	IR Spectrometer	864
Nitrogen Oxides	Thermo Electron Co.	Chemiluminescent	10A
Particulates	Andersen Samplers, Inc.	EPA Method 5 Train	EPA
Sulfur Dioxide	DuPont Instruments	UV Spectrometer	400
Particle Sizing	Andersen Samplers, Inc.	Cascade Impactor	Mark III
Smoke Spot	Bacharach	ASTM 2156-65	RCC
Opacity		EPA Method 9	
Sulfur Oxides (SO_x)		Goksoyr-Ross	

A-1.1 GAS SAMPLING AND CONDITIONING SYSTEM

A flow schematic of the flue gas sampling and analyzing system is shown in Figure A-2. The sampling system uses three positive-displacement diaphragm pumps to continuously draw flue gas from the stack into the

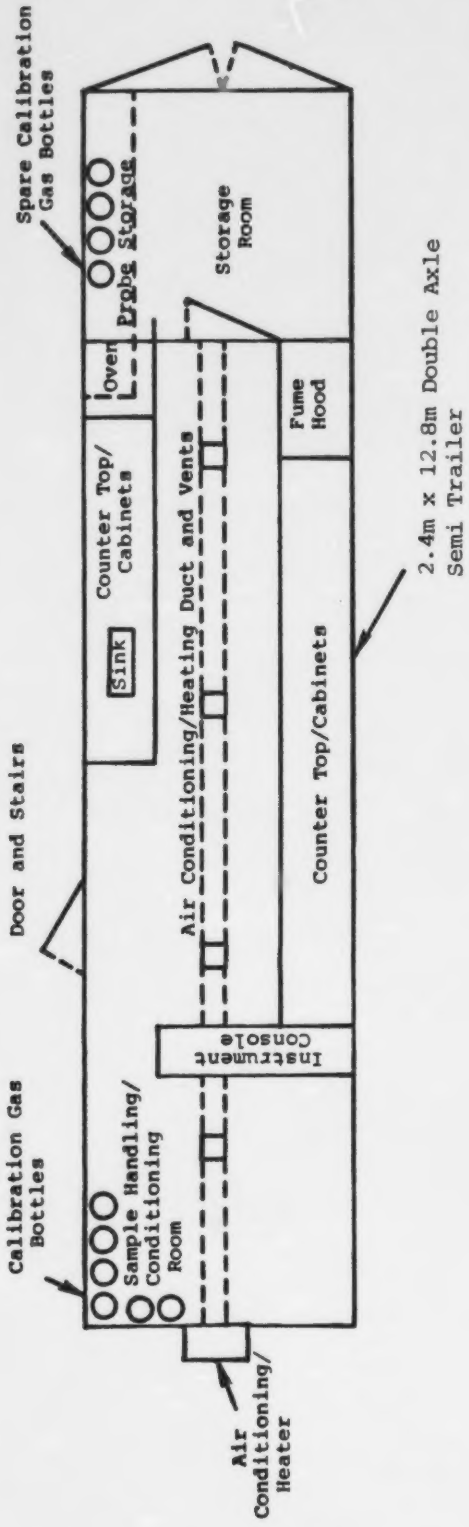

Figure A-1. Instrumentation trailer floor plan.

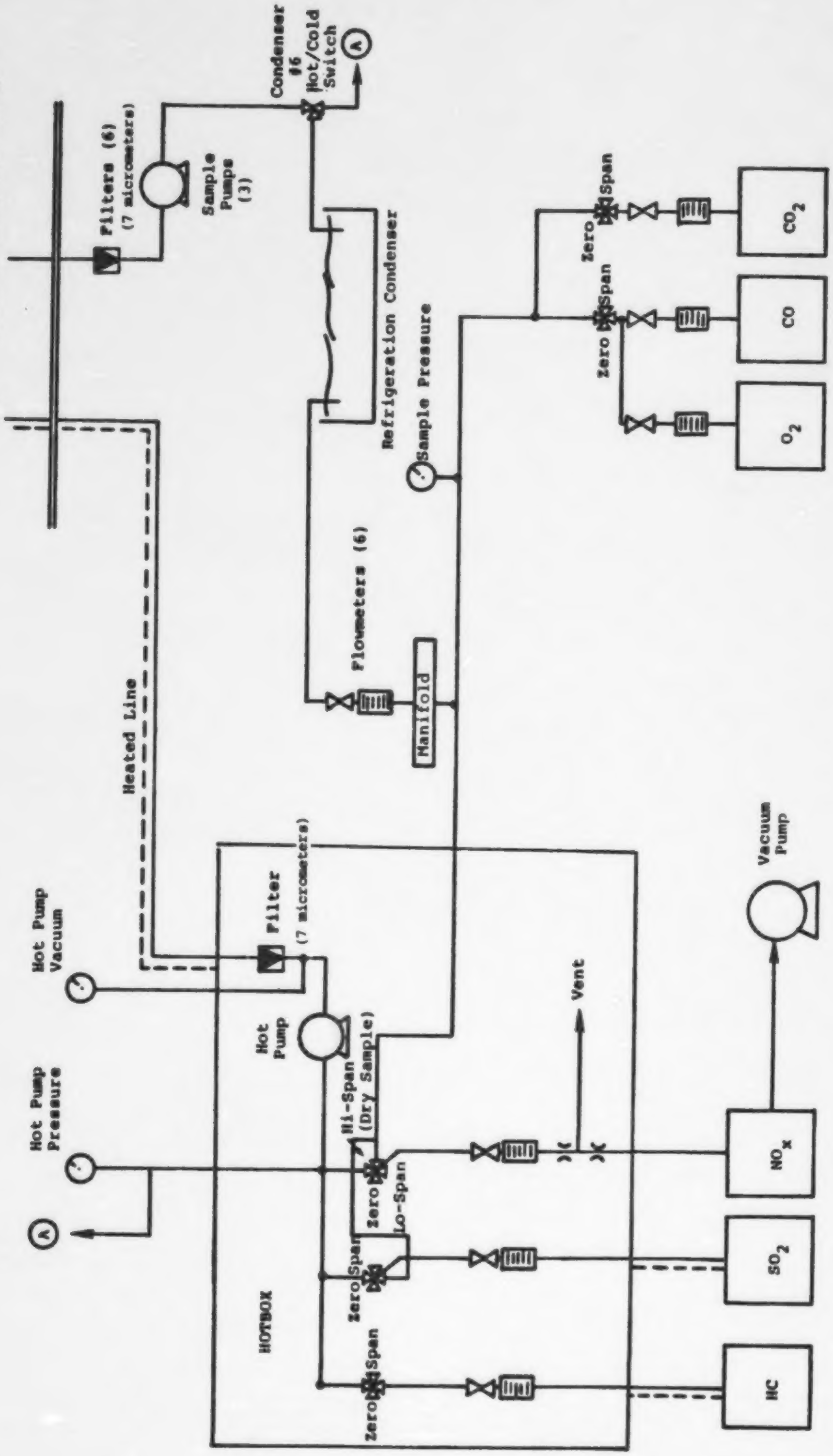

Figure A-2. Flue gas sampling and analyzing system.

laboratory. The sample pumps pull from six unheated sample lines. Selector valves allow composites of up to six points to be sampled at one time. The probes are connected to the sample pumps with 0.95 cm (3/8") or 0.64 cm (1/4") nylon line. The positive displacement diaphragm sample pumps provide unheated sample gas to the refrigerated condenser (to reduce the dew point to 35°F), a rotameter with flow control valve, and to the O_2, NO, CO, and CO_2 instrumentation. Flow to the individual analyzers is measured and controlled with rotameters and flow control valves. Excess sample is vented to the atmosphere.

To obtain a representative sample for the analysis of NO_2, SO_2 and hydrocarbons, the sample must be kept above its dew point, since heavy hydrocarbons may be condensible, and SO_2 and NO_2 are quite soluble in water. For this reason, a separate electrically-heated sample line is used to bring the sample into the mobile laboratory for analysis. The sample line is 0.95 cm (3/8-inch) Teflon line, electrically traced and thermally insulated to maintain a sample temperature of up to 478 K (400°F). A heated diaphragm pump provides hot sample gas to the hydrocarbon, SO_2 and NO_x analyzers.

A-1.2 INSTRUMENTAL CONTINUOUS MEASUREMENTS

The laboratory trailer is equipped with analytical instruments to continuously measure concentrations of NO, NO_2, CO, CO_2, O_2, SO_2, and hydrocarbons. All of the continuous monitoring instruments and sample handling system are mounted in the self-contained mobile laboratory. The entire system requires only connection to on-site water, power, and sampling lines to become fully operational. The instruments themselves are shock mounted on a metal console panel. The sample flow control measurement, and selection, together with instrument calibration are all performed from the console face. Three-pen recorders provide a continuous permanent record of the data taken. The sample gas is delivered to the analyzers at the proper condition and flow rate through the sampling and conditioning system described in the previous section. The sections below describe the analytical instrumentation.

A-1.2.1 Nitric Oxide (NO) and Total Nitrogen Oxides (NO_x)

Both the total nitrogen oxides (NO_x) and nitric oxide (NO) concentrations are measured from a sample gas obtained using a heated sample line at 394 K (250°F). In addition, the nitric oxide concentrations are measured sequentially from samples obtained using the unheated sample line that is connected to the same analyzer in the laboratory trailer. In the latter case, water is first removed from the sample gas by a refrigeration unit. The analytical instrument that is used for all of these measurements is the Thermo Electron Model 10A chemiluminescent gas analyzer.

For NO analyses, the sample gas is passed directly into the reaction chamber where a surplus of ozone is maintained. The reaction between the NO and the ozone produces light energy proportional to the NO concentration which is detected with a photomultiplier and converted to an electrical signal. Air for the ozonator is drawn from ambient through an air dryer and a 10-micrometer filter element.

The chemiluminescent reaction with ozone is specific to NO. To detect NO_2, a thermal converter has been designed to dissociate the NO_2 to NO by the bi-molecular reaction: $2\ NO_2 \rightarrow 2\ NO + O_2$. A model 700 thermal converter is used in conjunction with the chemiluminescent gas analyzer as shown in Figure A-3. The converter is a coil of resistance-heated stainless steel tubing whose purpose is to drive the NO_2/NO ratio to its chemical equilibrium value at the converter temperature and pressure. The unit is designed to operate at a temperature of 923 K (1200 °F) and pressure of .3 kPa (10 torr). For these conditions and typical stack gas O_2 concentrations, the equilibrium NO_2 concentration is 0.2 percent of the total NO_x concentration. Therefore, when a gas sample containing any NO_2 is passed through the converter, essentially all the NO_2 would be converted to NO. The resulting total NO is then measured using the chemiluminescent analyzer and the difference between the actual NO and the "total NO" would be the sample NO_2 concentration. The "total NO" is interpreted as NO_x.

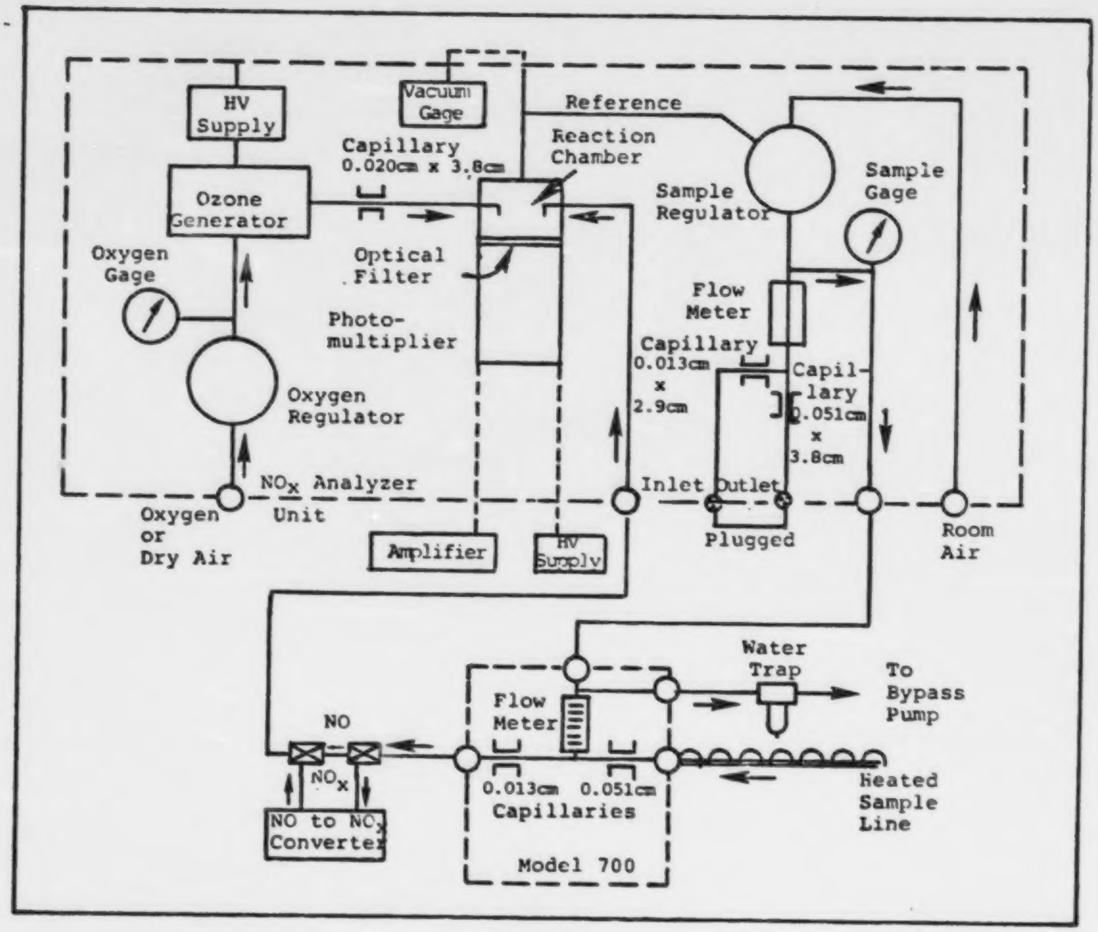

Figure A-3. Schematic of NO_x/NO chemiluminescent analysis system.

NO_2 may react upon contact with H_2O (liquid phase) to form HNO_3 (nitric acid). Under field test conditions, the exhaust gas may contain significant H_2O (depending upon the process and the ambient meteorological conditions), and it is necessary to convert the NO_2 to NO before the H_2O is allowed to condense in the sampling system. By using the heated sample line and the Thermo Electron Model 700 heated NO_x module, NO_2 concentrations will effectively be measured. In reference to Figure A-3, the sample is maintained above the H_2O dew point up to and through the 127 μm (0.005 in.) capillary in the heated module. Downstream of this capillary, the flow network is maintained at 1.3 kPa (10 torr), where the partial pressure of the H_2O in the sample is sufficiently low to prevent any condensation at ambient temperature.

When using the heated system, NO, NO_2, and NO_x are measured on a wet basis. When not using the heated system, a condenser is placed upstream of the analyzer and NO is measured on a dry basis.

Specifications

Accuracy: 1% of full scale

Span stability: ± 1% of full scale in 24 hours

Zero stability: ± 1 ppm in 24 hours

Power requirements: 115 ± 10V, 60 Hz, 1000 watts

Response: 90% of full scale in 1 sec (NO_x mode);
0.7 sec (NO mode)

Output: 4-20 ma

Sensitivity: 0.5 ppm

Linearity: ± 1% of full scale

Vacuum detector operation

Range: 2.5, 10, 25, 100, 250, 1000, 2500, 10,000 ppm full scale

A-1.2.2 Carbon Monoxide and Carbon Dioxide (CO and CO_2)

Carbon monoxide and carbon dioxide concentrations are measured using Beckman Model 864 and 865 short-path-length nondispersive infrared analyzers (see Figure A-4). These instruments measure the differential in infrared energy absorbed from energy beams passed through a reference cell (containing a gas selected to have minimal absorption of infrared energy in the wavelength absorbed by the gas component of interest) and a sample cell through which the sample gas flows continuously. The differential absorption appears as a reading on a scale of 0% to 100% and is then related to the concentration of the species of interest by calibration curves supplied with the instrument. A linearizer is supplied with each analyzer to provide a linear output over the range of interest. The operating ranges for the CO analyzer are 0-100 and 0-2000 ppm, while the ranges for the CO_2 analyzer are 0-5% and 0-20%.

Specifications

Span stability: ± 1% of full scale in 24 hours

Zero stability: ± 1 ppm in 24 hours

Ambient temperature range: 273 to 322 K (32°F to 120°F)

Line voltage: 115 ± 15V rms

Response: 90% of full scale in 0.5 or 2.5 sec

Linearity: Linearizer board installed for one range

Precision: ± 1% of full scale

Output: 4-20 ma

A-1.2.3 Oxygen (O_2)

A Teledyne Model 326A oxygen analyzer is used to automatically and continuously measure the oxygen content of the flue gas sample. The analyzer utilizes a micro-fuel cell which is specific for oxygen, has an absolute zero, and produces a linear output from zero through 25 percent oxygen. The micro-fuel cell is a sealed electrochemical transducer with no electrolyte to change or electrodes to clean. Oxygen in the flue gas diffuses through a Teflon membrane and is reduced on the surface of the cathode. A corresponding

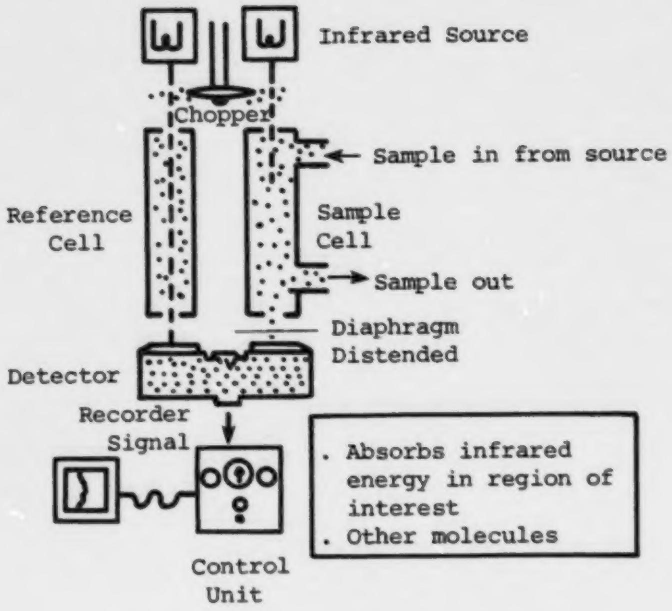

Figure A-4. Schematic of NDIR analyzer.

oxidation occurs at the anode internally and an electric current is produced that is proportional to the concentration of oxygen. This current is measured and conditioned by the instrument's electronic circuitry to give an output in percent O_2 by volume for operating ranges of 0% to 5%, 0% to 10%, and 0% to 25%.

Specifications

Precision: ± 1% of full scale

Response: 90% in less than 40 sec

Sensitivity: 1% of low range

Linearity: ± 1% of full scale

Ambient temperature range: 273 K to 325 K (32°F to 125°F)

Fuel cell life expectancy: 40,000% +-hrs

Power requirement: 115 VAC, 50-60 Hz, 100 watts

Output: 4-20 ma

A-1.2.4 Total Hydrocarbons (HC)

Hydrocarbon emissions are measured using a Beckman Model 402 high-temperature hydrocarbon analyzer. The analyzer utilizes the flame ionization method of detection which is a proven technique for a wide range of concentrations (0.1 to 120,000 ppm). A flow schematic of the analyzer is presented in Figure A-5. The sensor is a burner where a regulated flow of sample gas passes through a flame sustained by regulated flows of air and a premixed hydrogen/nitrogen fuel gas. Within the flame the hydrocarbon components of the sample stream undergo a complex ionization that produces electrons and positive ions. Polarized electrodes collect these ions, causing current to flow through electronic measuring circuitry. Current flow is proportional to the rate at which carbon atoms enter the burner.

The analysis occurs in a temperature-controlled oven. The sample is extracted from the stack with a stainless steel probe which has been thermally treated and purged to eliminate any hydrocarbons existing in the probe itself. An insulated heat-traced teflon line is used to transfer the sample

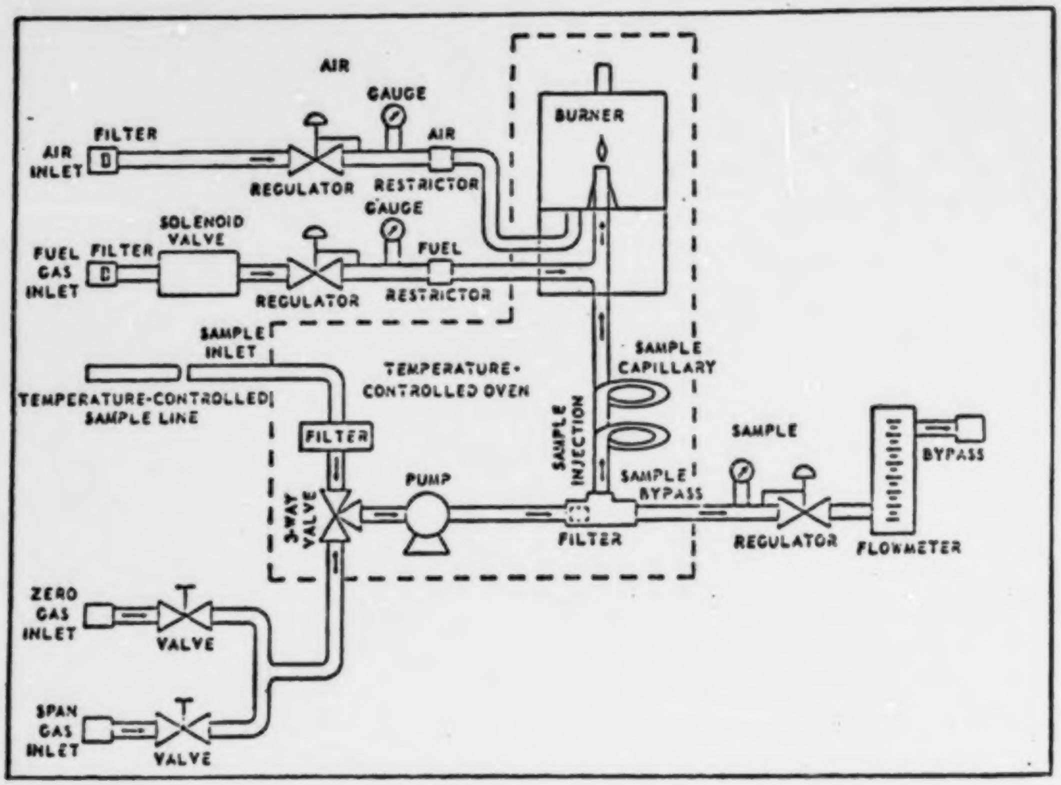

Figure A-5. Flow schematic of hydrocarbon analyzer (FID).

to the analyzer. The entire heated network is maintained at a temperature sufficient to prevent condensation of heavier hydrocarbons.

The flame ionization detector is calibrated with methane, and the total hydrocarbon concentration is reported as the methane equivalent. FID's do not respond equally to all hydrocarbons but generally provide a measure of the carbon-hydrogen bonds present in the molecule. The FID does not detect pure carbon or hydrogen.

Specifications

Full-scale sensitivity: adjustable from 5 ppm CH_4 to 10% CH_4

Ranges: Range multiplier switch has 8 positions: X1, X5, X10, X50, X100, X500, X1000, and X5000. In addition, span control provides continuously variable adjustment within a dynamic range of 10:1

Response time: 90% full scale in 0.5 sec

Precision: ± 1% of full scale

Electronic stability: ± 1% of full scale per 24 hours with ambient temperature change of less than 5.6 K (10°F)

Reproducibility: ± 1% of full scale for successive identical samples

Analysis temperature: ambient

Ambient temperature: 273 K to 317 K (32°F to 100°F)

Output: 4-20 ma

Air requirements: 250 to 400 cc/min of clean, hydrocarbon-free air, supplied at 2.07×10^5 to 1.38×10^6 n/m^2 (30 to 200 psig)

Fuel gas requirements: 75 to 80 cc/min of fuel consisting of 100 percent hydrogen supplied at 2.07×10^5 to 1.38×10^6 n/m^2 (30 to 200 psig)

Electric power requirements: 120 V, 60 Hz

Automatic flame indication and fuel shut-off valve

A-1.2.5 Sulfur Dioxide (SO_2)

A Dupont Model 400 photometric analyzer is used for measuring SO_2. This analyzer measures the difference in absorption of two distinct wavelengths (ultraviolet) by the sample. The radiation from a selected light source passes through the sample and then into the photometer unit where the radiation is split by a semi-transparent mirror into two beams. One beam is directed to a phototube through a filter which removes all wavelengths except the "measuring" wavelength, which is strongly absorbed by the constituent in the sample. A second beam falls on a reference phototube, after passing through an optical filter which transmits only the "reference" wavelength. The latter is absorbed only weakly, or not at all, by the constituent in the sample cell. The phototubes translate these intensities to proportional electric currents in the amplifier. In the amplifier, full correction is made for the logarithmic relationships between the ratio of the intensities and concentration or thickness (in accordance with Beer's Law). The output is therefore linearly proportional, at all times, to the concentration and thickness of the sample. The instrument has a lower detection limit of 2 ppm and full scale ranges of 0-200 and 0-2000 ppm.

Specifications

Noise: Less than 1/4%

Drift: Less than 1% full scale in 24 hours

Accuracy: (± 1% of analyzer reading) + (± 1/4% of full scale range)

Sample cell: 304 stainless steel, quartz windows

Flow rate: 0.05 dm^3/s (6 cfh)

Light source: Either mercury vapor, tungsten, or "Osram" discharge type lamps

Power rating: 500 watts maximum, 115 V, 60 Hz

Reproducibility: 1/4% of scale

Electronic response: 90% in 1 sec

Sample temperature: 378 K (220°F)

Output: 4-20 ma d.c.

A-1.3 PARTICULATE MATTER TOTAL MASS CONCENTRATION

Particulate matter is collected by filtration and wet impingement in accordance with US-EPA Method No. 5. Nomograph techniques are utilized to select the proper nozzle size and to set the isokinetic flow rates.

Gas samples for particulate sampling can be taken from the same sample port as those for gas analysis and passed through the Joy Manufacturing Company Portable Effluent Sampler. This system, which meets the EPA design specifications for Test Method 5, Determination of Particulate Emissions from Stationary Sources (Federal Register, Volume 36, No. 27, page 24888, December 24, 1971, and revisions thereof) is used to perform both the initial velocity traverse and the particulate sample collection.

Dry particulates are collected in the heated case that may contain a cyclone to separate particles larger than 5 µm and a 110-mm glass-fiber filter to retain particles as small as 0.3 µm. Condensible particulates are collected in four Greenburg-Smith impingers immersed in a chilled water bath.

The sampling probe is positioned through an exhaust port and attached to the sampling box. The probe consists of a sampling nozzle, heated probe, gaseous probe, thermocouple, and pitot tube. The ball joint from the heated probe connects to the cyclone and glass filter holder assembly. These assemblies are positioned in the heated sampling box which is maintained at 394 K (250°F), in order to eliminate condensation. The sample then passes from the heated section to four Greenburg-Smith impingers immersed in an ice bath. Only the second impinger has the original tip, the other three have had the tip removed to decrease the pressure drop through them. The first and second impingers are filled with 150 milliliters of distilled/deionized water. The third impinger is left dry. The fourth impinger is filled with approximately 200 grams of indicating silica gel to remove entrained water. The use of silica gel assures that a dry sample is delivered to the meter box. After sampling, the spent silica gel is discarded and not used for any further analysis.

An umbilical cord connects the last impinger, the pitot tube, and the heating elements to the meter box which is located in a convenient place within 15 m of the sampling ports. The meter box contains a vacuum pump, regulating valves, instantaneous and integrating flow meters, pitot tube manometers, vacuum gauge, and electrical controls.

Particulate matter (solids and condensibles) is collected in three discrete portions by the sampling train: the probe and glassware upstream of the filter; the filter; and the wet impingers. The probe and glassware are brushed and rinsed with acetone; the matter is captured for gravimetric analysis. The probe and glassware are then rinsed with distilled water and the rinsings transferred to a second container for analysis. The filter is desiccated and analyzed gravimetrically. The combined impinger liquid is heated to drive off uncombined water and the residue retained for analysis. The particulate matter analysis is illustrated schematically in Figure A-6.

US EPA Method 5 considers the particulate matter captured in containers (1) and (3); the filter, probe brushing, and probe acetone rinse. As EPA source standards are based on solid particulates only, care is taken to differentiate between solid and the total (including condensible) particulates. The water wash is performed because KVB's test experience has shown that a significant amount of water-soluble material may sometimes be captured by the probe.

The dry sample volume is determined with a dry test meter at a measured temperature and pressure and then converted to standard conditions. The volume of condensed water in the impingers is measured in milliliters and the corresponding volume of water vapor is then computed at standard conditions. The dry sample volume and water vapor volume are then summed to give the total sample volume. The dry sample volume is used in the data reduction procedures.

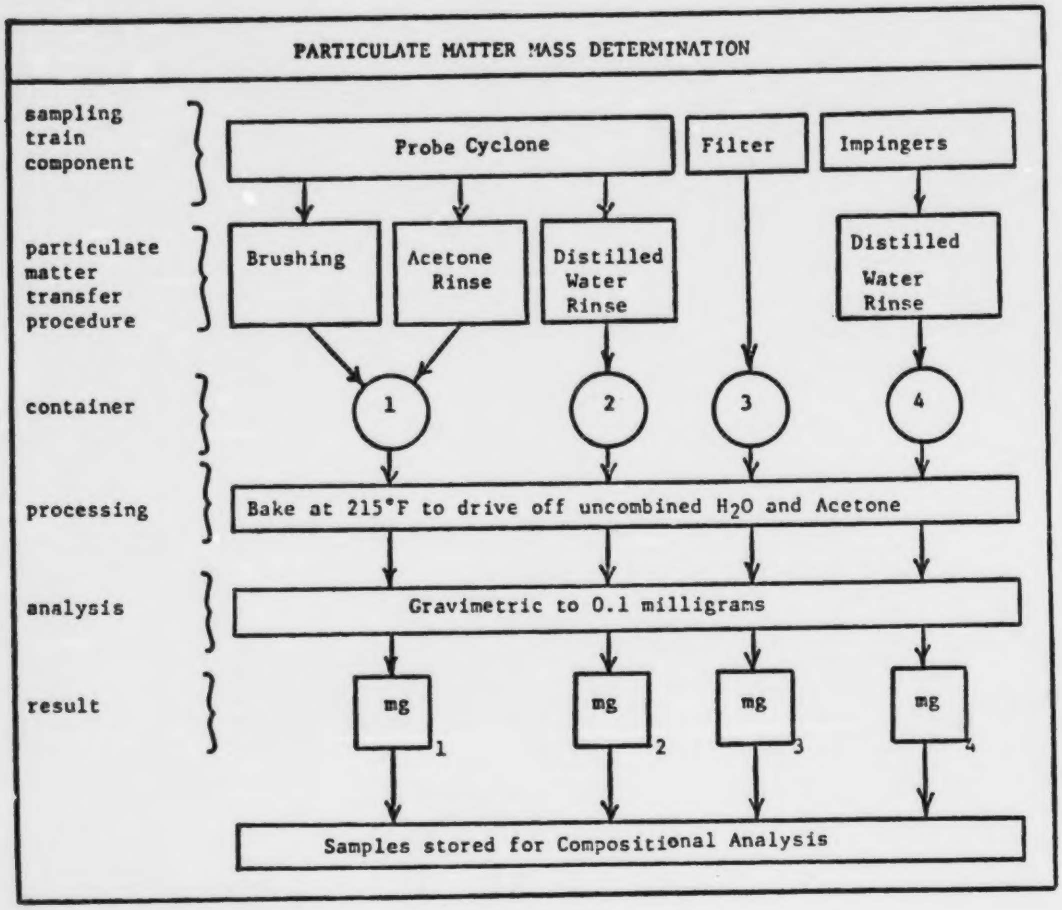
PARTICULATE MATTER MASS DETERMINATION
sampling train component
particulate matter transfer procedure
container
processing
analysis
result
Probe Cyclone
Filter
Impingers
Brushing
Acetone Rinse
Distilled Water Rinse
Distilled Water Rinse
1
2
3
4
Bake at 215°F to drive off uncombined H_2O and Acetone
Gravimetric to 0.1 milligrams
mg_1
mg_2
mg_3
mg_4
Samples stored for Compositional Analysis

Figure A-6. Processing and analyzing particulate matter.

A point of interest is the method chosen to calculate particulate emissions in ng/J or lb/10^6 Btu from the experimental data. The particulate sampling train, properly operated, yields particulate mass per unit flue gas volume. Having measured g/m^3, it is necessary to establish the flue gas volume per unit heat input if emissions in ng/J are desired. The original Method 5 involved determining a velocity traverse of the stack, the cross-sectional area, the flue flow rate, and fuel heating value. A revised and more accurate method has been promulgated by the Environmental Protection Agency that utilizes a fuel analysis (carbon content, hydrogen content, high heating value, etc.) and the measured O_2 in the exhaust to calculate the gas volume generated in liberating 1.055 GJ (one million Btu's). The velocity traverse approach generally results in a 20 to 30 percent higher value and is believed to be less accurate.

A-1.4 SMOKE SPOT

On combustion equipment where smoke numbers normally are taken, such as oil-fired boilers, KVB, Inc. determines the smoke number using test procedures according to ASTM Designation: D 2156-65. The smoke number is determined at each combustion modification setting of the unit. Examples are baseline, minimum excess air, low load, etc., and whenever a particulate concentration is measured.

Smoke spots are obtained by pulling a fixed volume of flue gas through a fixed area of a standard filter paper. The color (or shade) of the spots that are produced is visually matched with a standard scale. The result is a "Smoke Number" which is used to characterize the density of smoke in the flue gas.

The sampling device is a hand pump similar to the one shown in Figure A-7 . It is a commercially available item that can pass 36,900 ± 1650 cu cm of gas at 289K and 1 atmosphere pressure through an enclosed filter paper for each 6.5 sq cm effective surface area of the filter paper.

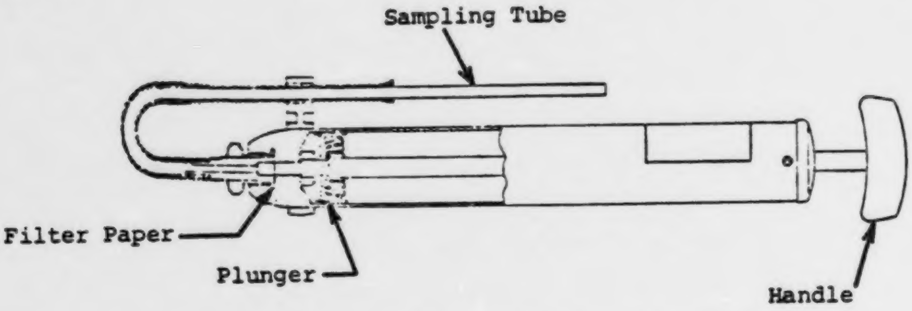

Figure A-7. Field-service-type smoke tester.

The smoke spot sampler is provided with a motor-driven actuator to ensure a constant sampling rate independent of variations in stroke rate that can occur when the sampler is operated manually.

The smoke scale required consists of a series of ten spots numbered consecutively from 0 to 9, and ranging in equal photometric steps from white through neutral shades of gray to black. The spots are imprinted or otherwise processed on white paper or plastic stock having an absolute surface reflectance of between 82.5 and 87.5%, determined photometrically. The smoke scale spot number is defined as the reduction (due to smoke) in the amount of light reflected by a soiled spot on the filter divided by 10.

Thus the first spot, which is the color of the unimprinted scale, is No. 0. In this case there is no reduction in reflected incident light directed on the spot. The last spot, however, is very dark, reflecting only 10% of the incident light directed thereon. The reduction in reflected incident light is 90%, and this spot is identified as No. 9. Intermediate spot numbers are similarly established. Limits of permissible reflectance variation of any smoke scale spot will not exceed ± 3% relative reflectance.

The test filter paper is made from white filter paper stock having absolute surface reflectance of 82.5 to 87.5%, as determined by photometric measurement. When making this reflectance measurement, the filter paper is backed by a white surface having absolute surface reflectance of not less than 75%.

When clean air at standard conditions is drawn through clean filter paper at a flow rate of 47.6 cu cm per sec per sq cm effective surface area of the filter paper, the pressure drop across the filter paper falls between the limits of 1.7 and 8.5 kPa (1.3 and 6.4 cm of mercury).

The sampling procedure is exactly that specified in D 2156. A clean, dry, sampling pump is used. It is warmed to room temperature to prevent condensation on the filter paper. When taking smoke measurements in the flue pipe, the intake end of the sampling probe is placed at the center line of the flue. When drawing the sample, the pressure in the flue gas stream and the sampler is allowed to equalize after each stroke.

The smoke density is reported on the Mobile Lab Data Sheet as the Smoke Spot Number on the standard scale most closely corresponding to test spot. Differences between two standard Smoke Spot Numbers are interpolated to the nearest half number. Smoke Spot Numbers higher than 9 are reported as "Greater than No. 9."

This procedure is deemed to be reproducible to within ± 1/2 of a Smoke Spot Number under normal conditions where no oily stain is deposited on the disk.

KVB's field experience with industrial boilers has been that the human factor involved in the interpretation of the smoke spot by an experienced observer does not cause a significant lack of precision.

A-1.5 OPACITY

Opacity readings are taken by a field crew member who is a certificated graduate of a U.S. Environmental Protection Agency approved "Smoke School". Observations are made at the same time that particulate measurements are made and as often in addition as deemed necessary to gather the maximum amount of information. The procedures set forth in EPA Method 9, "Visual Determinations of the Opacity of Emissions for Stationary Sources" are followed.

Observations are made and recorded at 15 second intervals while particulate concentration is being measured and after the unit has stabilized at other times. Before beginning observations, the observer determines that the feedstock or fuel is the same as that from which the sample was taken for the fuel analysis.

Before beginning opacity observations, the observer makes arrangements with the combustion unit operator to obtain the necessary process data for the standard KVB Control Room Data Sheet. The control room data are recorded for the entire period of observations, as is customarily done by KVB during an emissions test. The process unit data that are obtained include:

a. Production rates
    1. maximum rated capacity
    2. actual operating rate during test
b. Control device data
    1. recent maintenance history
    2. cleaning mechanism and cycle information

The observer requests the appropriate plant personnel to briefly review and comment on the opacity measurements and process data and the observer comments on:

a. the basis for choosing the observation periods used.

b. why it is believed the periods chosen constitute periods of greatest opacity.

c. why the observations span a time period sufficient to characterize the opacity.

Consideration is given to postponing the EPA Method 5 particulate tests during periods of cloudy or rainy weather because of the inability of the observer to monitor the smoke.

A-1.5.1 Sulfur Oxides (SO_x)

Goksoyr-Ross Method--Wet Chemical Method

The Goksoyr-Ross Controlled Condensate (G/R) method is used for the wet chemical SO_2/SO_3 determination. It is a desirable method because of its simplicity and clean separation of particulate matter, SO_2 and H_2SO_4 (SO_3). This procedure is based on the separation of H_2SO_4 (SO_3) from SO_2 by cooling the gas stream below the dew point of H_2SO_4 but above the H_2O dew point. Figure A-8 illustrates schematically the G/R test system.

Particulate matter is first removed from exhaust gas stream by means of a quartz glass filter placed in the heated glass filter holder. Tissue-quartz filters are recommended because of their proven inertness to H_2SO_4. The filter system is heated by a heating tape so that the gas out temperature of 533 K (500°F) is maintained. This temperature is imperative to ensure that none of the H_2SO_4 will condense in the filter holder or on the filter.

The condensation coil where the H_2SO_4 is collected is cooled by water which is maintained at 333 K (140°F) by a heater/recirculator. This temperature is adequate to reduce the exhaust gas to below the dew point of H_2SO_4.

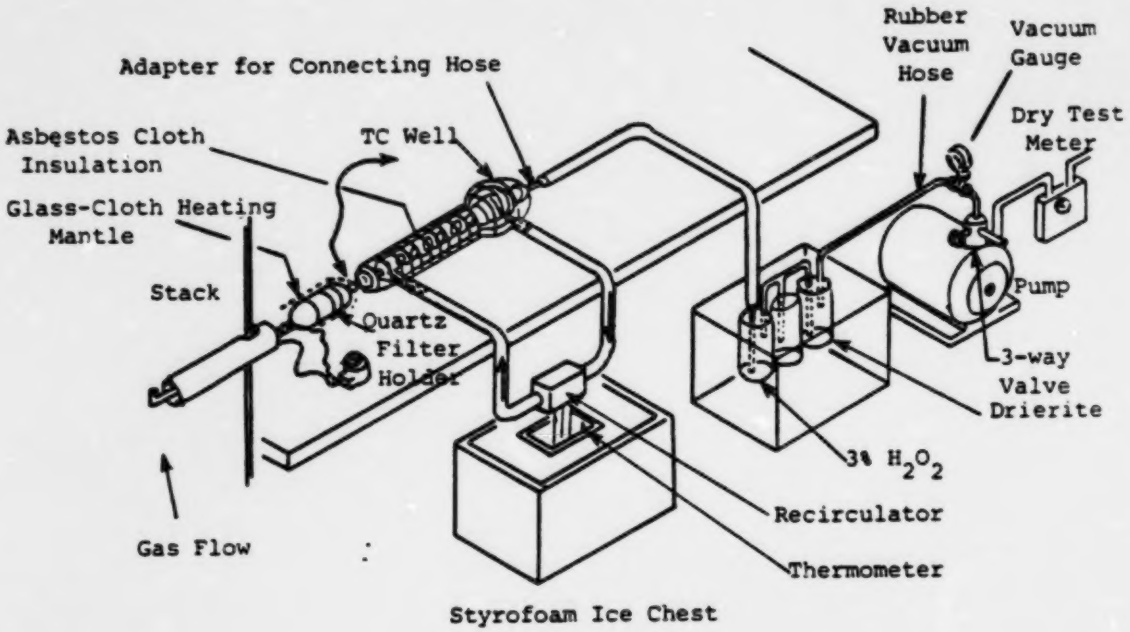

Figure A-8. Schematic of Goksoyr-Ross controlled condensation system (CCS).

Three impingers are shown in Figure A-8. The first impinger is filled with 3 percent H_2O_2 to absorb SO_2. The second impinger is to remove carryover moisture and the third contains Drierite and a thermometer to measure the exhaust gas temperature to the dry gas meter and pump. The sampling rate is 0.04 dm^3/s (0.08 cfm).

A-1.5.2 Analysis Procedure

For both SO_2 and H_2SO_4 determination, the analytical procedure is identical. The H_2SO_4 sample is washed from the back part of the filter holder and the coil using a 5 percent isopropyl alcohol solution. The sample from the first impinger which is assumed to be absorbed and reacted SO_2 in the form of H_2SO_4 is recovered with distilled water washing. The amount of H_2SO_4 in the condensate from the coil and from the H_2O_2 impinger is measured by H+ titration. Bromphenol Blue is used with NaOH as the titrant.

A-1.6 PARTICLE SIZE DISTRIBUTION

An Anderson Mark III in stack particle fractionating sampler was used for the particle size distribution tests (Figure A-9).

A-1.6.1 Design

The Anderson stack sampling has been designed to operate with the EPA Method 5 train. The stack head consists of a stainless steel case and 1/2" (1.3 cm) NPT female pipe fittings. The stack sampler contains nine jet plates, each having a pattern of precision drilled orifices. Special collection substrates, (e.g., glass fiber, aluminum foil, etc.) placed on the jet/collection plates, permit lighter tare weights for gravimetric analyses and a variety of collection materials for chemical analysis. The sampler may be used with or without the collection substrate. The nine plates are separated by 2.5 millimeter stainless steel spacers. The jets on each plate are arranged in modified concentric circles which are offset on each succeeding plate. The size of the orifices is the same on a given plate, but smaller for each succeeding downstream plate. Therefore, as the sample is drawn through the sampler at a constant flow rate, the jets of air flowing through any

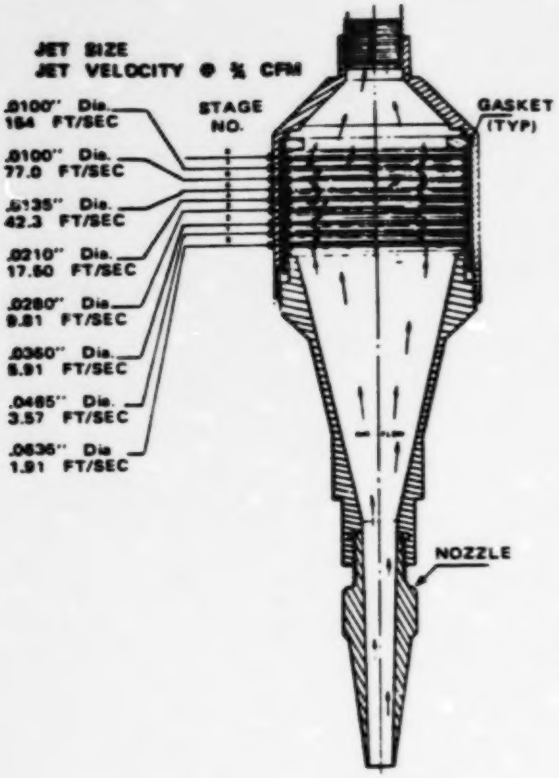

Figure A-9.
Impactor Head

particular plate direct the particles toward the collection substrate on the downstream plate directly below the circles of jets on the plate above. Since the jet diameters decrease from plate to plate, the velocities increase such that whenever the velocity imparted to a particle is sufficiently great, its inertia will overcome the aerodynamic drop of the turning air stream and the particle will be impacted on the collection substrate. Otherwise, the particle remains in the air stream and proceeds to the next plate.

Since the particle deposit areas are directly below the jets, seven of the plates act as both a jet stage and a collection plate. Thus, No. 0 plate is only a jet stage and No. 8 plate is only a collection plate.

The stack sampler is designed to operate at 0.35 dm^3/s (0.75 acfm) or less. An optimum flow rate is around 0.24 dm^3/s (0.5 acfm).

A-1.6.2 Operation

An EPA Method 5 train is used to draw a sample of the flue gas through the impactor. All particles entrained in the air stream are inertially impacted on the preweighed collection surfaces. The size ranges of particles deposited is from >10 microns with preseparator to <0.4 microns on the last stage. It is recommended that the preseparator be used to remove the larger particles when conditions warrant and it is necessary to use a backup filter always to ensure total collection. The collection media used during the test series were glass fiber filters. The filters were preconditioned for weighing before and after a sampling cycle in a desiccator.

Normal sampling periods vary from a few minutes to several hours depending on the grain loading situation. Ten milligrams of particulate matter on any one plate represents an approximate upper limit because of re-entrainment problems. Overloading the sampler can be detected easily by visual inspection and occurs more often during the first test at an unfamiliar stack. After the sampling cycle has been completed, the sampler is disassembled. After the desiccating of the collection media, weighing is performed to determine the net particulate accumulations.

A-1.6.3 Data Presentation

To determine the concentration of particulates for any size range, first determine the percentage of total particulates for each stage. Then the cumulative percentage is determined beginning with the last stage of the impactor. By plotting the effective cutoff diameter (ECD) and the cumulative percent on logarithmic probability graph paper, then the particle concentration by weight for any specific size can be determined.

APPENDIX B

FIELD TEST DATA SUMMARY FOR A FULL-SCALE PROCESS HEATER

TABLE B-1

TABLE B-1. EMISSIONS SUMMARY: REFINERY PROCESS HEATER, SET 1

TEST#	DATE'80	FUEL% NG-FG/AG/#6	PROC. RATE CM/H	HEAT INPUT MW	O2 %	CO2 %	NO PPM*	NO NG/J	CO PPM*	SO2 PPM*	SMOKE SPOT	STACK T K	STACK T F	HTR EFF %	SEC.AIR REG. % OPEN	STAGE HT. M	STAGE HT. FT	BRN. STOIC RATIO	COMMENTS
7/1-1	6-11	100/0/0	74.9	11.3	3.9	9.1	91	46	29	0	--	654	717	72.7	50	--	--	--	BASELINE,GAS,MED.LD
7/1-2	6-11	100/0/0	74.9	10.8	2	11	86	44	0	0	--	635	683	76.0	50	--	--	--	LOW O2,GAS,MED.LD.
7/1-3	6-11	100/0/0	74.9	11.6	5.6	8.6	102	52	0	0	--	667	740	59.3✓	50	--	--	--	HIGH O2,GAS,MED.LD.
7/1-4	6-12	100/0/0	74.9	10.9	.9	12	64	32	0	0	--	634	682	76.5	50	--	--	--	SMOKE LIM.,GAS,MED.LD.
7/2-1	6-12	100/0/0	94.1	15.8	3.3	9.7	82	41	23	0	--	687	777	72.5	50	--	--	--	MED.LO O2,GAS,HI LD.
7/2-2	6-12	100/0/0	94.1	15.9	4.2	9.3	82	41	0	0	--	693	788	71.5	50	--	--	--	BASELINE,GAS,HI LD.
7/2-3	6-12	100/0/0	94.1	15.4	1.9	11	69	35	0	0	--	676	757	74.3	50	--	--	--	LOW O2,GAS,HI LD.
7/2-4	6-12	100/0/0	94.1	16.3	4.5	9.5	83	42	0	0	--	695	791	71.6	50	--	--	--	HI O2,GAS,HI LD.
7/3-1	6-13	100/0/0	55	8.6	8.7	5.8	92	47	0	0	--	654	717	64.7✓	50	--	--	--	HI O2,GAS,LOW LOAD
7/3-2	6-13	100/0/0	55	7.9	5.6	8.3	94	48	0	0	--	622	659	72.7	50	--	--	--	BASELINE,GAS,LO LD.
7/3-3	6-13	100/0/0	55	7.9	4.2	9.2	87	44	0	0	--	609	637	74.7	50	--	--	--	MED.LO O2,GAS,LO LD
7/3-4	6-13	100/0/0	55	7.4	2.3	9.9	58	29	0	0	--	596	613	76.2	50	--	--	--	LO O2,GAS,LOW LD.
7/4-1	6-16	55/0/45	76.2	11.4	4.25	11.8	215	.13	0	830	1.8	654	717	76.8	50	--	--	--	BASELINE,GAS-OIL,MED. LD
7/4-2	6-16	55/0/45	76.2	11.4	5.7	9.8	224	118	0	1166	1	668	742	74.6	50	--	--	--	HI O2,GAS-OIL,MED. LD.
7/4-3	6-17	37/0/63	76.2	11.4	3.8	12.8	188	101	0	84	2	651	712	78.8	50	--	--	--	MED.O2,GAS-OIL,MED.LD.
7/4-4	6-17	37/0/63	76.2	11.4	2.2	16.8	153	82	0	77	6.5	642	696	81.7	50	--	--	--	LO O2,GAS-OIL,MED. LD.
7/4-5	6-17	37/0/63	76.2	11.4	1.25	16	120	64	18	111	9	631	675	75.6✓	50	--	--	--	CO LIM.,GAS-OIL,MED. LD.
7/5-1	6-18	63/0/37	95.4	14.3	2.8	9.8	150	79	0	0	2	687	776	73.8	50	--	--	--	BASELINE,GAS-OIL,HI LD.
7/5-2	6-18	63/0/37	95.4	14.3	1.6	13.6	139	73	0	0	3.5	684	771	78.2	50	--	--	--	MED.LO O2,GAS-OIL,HI LD.
7/5-3	6-18	63/0/37	95.4	14.3	1.2	14	123	64	0	0	6.5	679	762	78.6	50	--	--	--	CO LIM.,GAS-OIL,HI LD.
7/5-4	6-18	63/0/37	95.4	14.3	2.9	12.9	162	85	0	0	1	691	784	77.4	50	--	--	--	HI O2,GAS-OIL,HI LD.
7/6-1	6-19	56/0/44	55	8.2	6.7	5.4	120	63	0	0	1	657	723	63.1✓	50	--	--	--	HI O2,GAS-OIL,LO LD.
7/6-2	6-19	56/0/44	55	8.2	4.8	8.6	170	90	0	0	1	622	660	74.6	50	--	--	--	BASELINE,GAS-OIL,LO LD.
7/6-3	6-19	56/0/44	55	8.2	2.9	9.8	166	88	0	0	2	605	629	77.4	50	--	--	--	MED.LO O2,GAS-OIL,LO LD.
7/6-4	6-19	56/0/44	55	8.2	1.7	10.4	142	75	0	0	4.5	597	614	78.6	50	--	--	--	LO O2,GAS-OIL,LO LD.
7/7-1	6-20	54/0/46	94.1	14.1	3.4	9.8	164	87	0	118	4	691	783	73.7	50	--	--	--	HI O2, GAS-OIL,HI LD.
7/7-2	6-20	54/0/46	94.1	14.1	2.6	10.2	135	71	0	90	3.5	685	773	74.5	50	--	--	--	BASELINE,GAS-OIL,HI LD.
7/7-3	6-20	54/0/46	94.1	14.1	1.9	13.2	139	73	0	87	8	677	758	78.2	50	--	--	--	LO O2,GAS-OIL,HI LD.
7/8-1	6-20	100/0/0	76.2	9.7	6	8.8	122	62	0	0	--	691	783	71.8	50	--	--	--	MED.LD.,GAS,ATOM.STM.ON
7/8-2	6-20	100/0/0	76.2	9.7	3.1	10.6	110	56	0	0	--	685	773	74.0	50	--	--	--	BASELINE,GAS,MED. LD.
7/8-3	6-20	100/0/0	76.2	9.7	3.4	10.4	109	55	0	0	--	677	759	74.9	5	--	--	--	AIR REG.ADJ.,GAS,MED.LD.
7/9-1	6-25	0/100/0	76.2	11.5	4.1	9.4	106	54	0	0	--	667	740	70.1	50	--	--	1.22	BASELINE,GAS,MED.LD.
7/9-2	6-25	0/100/0	76.2	11.8	3.9	11	92	47	0	0	--	668	742	72.2	50	1.2	4	.96	4' STAGE HT.,GAS,MED.LD.
7/9-3	6-25	0/100/0	76.2	11.8	3.9	10.2	87	44	0	0	--	668	742	72.5	50	1.2	4	.89	4' STAGE HT.,GAS,MED.LD.
7/9-4	6-25	0/100/0	76.2	11.5	3.7	10	78	40	0	0	--	660	728	72.7	50	1.2	4	.8	4' STAGE HT.,GAS,MED.LD.
7/9-5	6-26	0/100/0	76.2	11.5	1.3	12	82	42	0	0	--	646	702	74.9	50	--	--	1.06	2% O2,GAS
7/9-6	6-26	0/100/0	76.2	11.3	2.2	11.8	72	37	0	0	--	653	716	74.5	50	1.2	4	.84	4' STAGE HT.,GAS,2% O2
7/9-7	6-26	0/100/0	76.2	11.1	2	11.4	63	32	0	0	--	649	709	74.2	50	1.2	4	.76	4' STAGE HT.,GAS,2% O2
7/9-8	6-26	0/100/0	76.2	11.1	2.3	11.4	60	31	0	0	--	647	705	74.3	50	1.2	4	.71	4' STAGE HT.,GAS,2% O2
7/10-1	6-26	0/100/0	76.2	11.6	4.1	7.9	109	56	0	0	--	669	745	68.0	50	--	--	--	BASELINE,GAS
7/10-2	6-26	0/100/0	76.2	11.8	4.2	7.6	96	49	0	0	--	672	750	67.3	50	.91	3	.96	3' STAGE HT.,GAS
7/10-3	6-26	0/100/0	76.2	11.8	4.3	7.2	93	47	0	0	--	672	749	66.2	50	.91	3	.9	3' STAGE HT.,GAS
7/10-4	6-26	0/100/0	76.2	11.8	4.2	7.4	86	44	0	0	--	668	743	66.9	50	.91	3	.84	3' STAGE HT.,GAS
7/10-5	6-27	0/100/0	76.2	11.8	3.6	10.2	106	54	0	0	--	667	740	71.9	50	--	--	1.19	BASELINE,GAS
7/10-6	6-27	0/100/0	76.2	11	1.7	10.6	93	47	0	0	--	650	710	73.5	50	--	--	1.08	2% O2,GAS
7/10-7	6-27	0/100/0	76.2	10.5	2.1	10.4	71	36	0	0	--	654	718	73.1	50	.91	3	.81	3' STAGE HT.,2% O2,GAS
7/10-8	6-27	0/100/0	76.2	10.5	1.9	10.6	69	35	0	0	--	651	712	73.6	50	.91	3	.79	3' STAGE HT.,2% O2,GAS
7/10-9	6-27	0/100/0	76.2	11.5	2.1	10	61	31	0	0	--	652	713	72.9	50	.91	3	.7	3' STAGE HT.,2% O2,GAS
7/11-1	6-28	0/100/0	76.2	11.1	3.9	8.1	110	56	0	0	--	661	730	69.0	50	--	--	1.2	BASELINE,GAS
7/11-2	6-28	0/100/0	76.2	11.1	3.8	9.6	94	48	0	0	--	656	720	72.0	50	.61	2	.93	2' STAGE HT.,GAS
7/11-3	6-28	0/100/0	76.2	11.1	4.1	9.8	98	50	0	0	--	662	731	72.0	50	.61	2	.88	2' STAGE HT.,GAS
7/11-4	6-28	0/100/0	76.2	11.1	4.1	9.1	96	49	0	0	--	661	730	71.1	50	.61	2	.81	2' STAGE HT.,GAS
7/11-5	6-28	0/100/0	76.2	11.1	2	8.6	99	51	0	0	--	650	710	71.0	50	--	--	1.09	2% O2,GAS

TABLE B-1. EMISSIONS SUMMARY (CONTINUED)

TEST#	DATE '80	FUEL& NG-FG/AG/#6	PROC. RATE CM/H	HEAT INPUT MW	O2 %	CO2 %	NO PPM*	NO NG/J	CO PPM*	SO2 PPM*	SMOKE SPOT	STACK T K	STACK T F	HTR EFF %	SEC.AIR REG. % OPEN	STAGE HT. M	STAGE HT. FT	BRN. STOIC RATIO	COMMENTS
7/11-6	6-28	0/100/0	76.2	11.1	2.1	11	77	39	0	0	--	647	704	74.5	50	.61	2	.82	2' STAGE HT.,2% O2,GAS
7/11-7	6-28	0/100/0	76.2	11.1	2	10.2	68	35	0	0	--	647	704	73.6	50	.61	2	.75	2' STAGE HT.,2% O2,GAS
7/11-8	6-28	0/100/0	76.2	11.1	1.9	11.4	54	28	0	0	--	644	699	75.0	50	.61	2	.69	2' STAGE HT.,2% O2,GAS
7/11-9	6-28	0/100/0	76.2	11.1	2	11.8	53	27	0	0	--	644	699	75.3	50	1.2	4	.7	4' STAGE HT.,2% O2,GAS
7/12-1	7-1	0/100/0	63.6	8.8	4.1	10	105	54	0	0	--	631	676	73.6	50	--	--	1.22	LOW LOAD BASELINE,GAS
7/12-2	7-1	0/100/0	63.6	9.2	4	10	89	45	0	0	--	632	677	73.6	50	1.2	4	.97	4' STAGE HT.,LO LD.,GAS
7/12-3	7-1	0/100/0	63.6	9.2	3.9	10.3	81	41	0	0	--	636	685	74.0	50	1.2	4	.88	4' STAGE HT.,LO LD.,GAS
7/12-4	7-1	0/100/0	63.6	9.2	4	10	77	39	0	0	--	637	686	73.6	50	1.2	4	.8	4' STAGE HT.,LO LD.,GAS
7/12-5	7-1	0/100/0	63.6	9.2	4.1	10.1	68	35	0	0	--	635	684	73.7	50	1.2	4	.74	4' STAGE HT.,LO LD.,GAS
7/12-6	7-1	0/100/0	63.6	9.2	1.6	11.6	65	33	0	0	--	624	663	76.1	50	1.2	4	.84	4' STAGE HT.,LO LD,LO O2
7/12-7	7-1	0/100/0	63.6	9.2	1.7	12	62	32	0	0	--	622	660	76.5	50	1.2	4	.78	4' STAGE HT.,LO LD,LO O2
7/12-8	7-1	0/100/0	63.6	9.2	2	11.3	55	28	0	0	--	623	661	75.9	50	1.2	4	.69	4' STAGE HT.,LO LD,LO O2
7/12-9	7-1	0/100/0	63.6	9.2	2	11.3	51	26	0	0	--	621	658	76.0	50	1.2	4	.65	4' STAGE HT.,LO LD,LO O2
7/12-10	7-1	0/100/0	63.6	9.2	2.1	11.3	90	46	0	0	--	626	667	75.8	50	--	--	1.1	2% O2,LO LD.,GAS
7/13-1	7-2	0/100/0	76.2	11.8	4	10.1	97	50	0	0	--	671	748	73.9	50	--	--	1.21	BASELINE,GAS
7/13-2	7-2	0/100/0	76.2	12.1	4.2	10	87	44	0	0	--	677	759	73.5	50	1.22	4	.98	STAGE HT.VARIATION,GAS
7/13-3	7-2	0/100/0	76.2	11.9	4.2	10	87	44	0	0	--	676	754	73.6	50	.91	3	.98	STAGE HT.VARIATION,GAS
7/13-4	7-2	0/100/0	76.2	11.9	4	10.3	87	44	0	0	--	--	--	--	50	.61	2	.96	STAGE HT.VARIATION,GAS
7/13-5	7-2	0/100/0	76.2	11.9	4.1	10.2	85	43	0	0	--	--	--	--	50	.3	1	.97	STAGE HT.VARIATION,GAS
7/14-1	7-8	0/46/54	76.2	11.4	4	10.2	207	111	31	238	9	653	715	74.6	50	--	--	1.21	BASELINE,GAS-OIL,SMOKE
7/14-2	7-8	0/46/54	76.2	11.4	4	10.1	230	123	0	238	5	657	722	74.1	50	1.22	4	.9	4' STAGE HT.,MED.LD
7/14-3	7-8	0/46/54	76.2	11.4	4	10	246	132	0	244	4.5	657	726	74.1	50	.91	3	.9	3' STAGE HT.,MED.LD
7/14-4	7-8	0/46/54	76.2	11.4	3.8	11	249	133	0	241	3	659	727	75.5	50	.61	2	.89	2' STAGE HT.,MED.LD
7/14-5	7-8	0/75/25	76.2	11.4	4	10	186	97	32	220	.5	665	737	74.2	50	--	--	1.21	REPT.BASELINE,CLN OIL GUN,INC.ATOM.STM.PRESS.
7/15-1	7-9	0/75/25	76.2	11.4	4.1	10.6	201	105	0	--	1	668	743	74.3	50	--	--	1.22	BASELINE,REG. 50% OPEN
7/15-2	7-9	0/72/28	76.2	11.4	4.1	10.6	205	107	0	178	1	668	742	74.5	90	--	--	1.22	NEW BASELINE,SEC.AIR REG 90% OPEN,BETTER FLAME
7/15-3	7-9	0/75/25	76.2	11.4	4	10.3	194	101	0	183	2	664	736	74.2	90	1.22	4	.9	4' STAGE HT.
7/15-4	7-9	0/72/28	76.2	11.4	4.1	10.8	199	104	0	135	1.5	663	733	74.8	90	.91	3	.9	3' STAGE HT.
7/15-5	7-9	0/72/28	76.2	11.4	4.2	10.6	206	108	0	185	1	659	727	74.8	90	.61	2	.91	2' STAGE HT.
7/15-6	7-11	0/72/28	76.2	11.4	4	11.1	211	110	0	189	1	665	737	75.3	90	--	--	1.22	BASELINE,GAS-OIL
7/15-7	7-11	0/72/28	76.2	11.4	4	11	193	101	0	183	1	663	733	75.6	90	1.22	4	.9	4' STAGE HT.
7/15-8	7-11	0/72 28	76.2	11.4	4.2	11	191	100	0	191	5	656	720	75.9	90	1.83	6	.91	6' STAGE HT.
7/15-9	7-11	0/69/31	76.2	11.4	4.1	11	190	100	0	172	0	621	657	77.4	90	2.44	8	.9	8' STAGE HT.,LOW STACK T
7/16-1A,B	7-15	90/0/10	76.2	11.4	4	10.6	200	102	0	681	1	672	750	74.5	50	--	--	1.22	BASELINE,REG.50% OPEN
7/16-2	7-15	91/0/9	76.2	11.4	4	10.6	178	91	0	354	0	672	750	74.4	50	1.22	4	.95	4' STAGE HT.LO STAGING
7/16-3	7-15	91/0/9	76.2	11.4	4.2	10.6	182	93	0	380	2	668	743	74.8	50	1.22	4	.9	MED.STAGING
7/16-4	7-15	93/0/7	76.2	11.4	4	10.6	166	85	0	158	2	668	742	74.8	50	1.22	4	.84	HI STAGING
7/16-5	7-15	0/69/31	76.2	11.4	2	10.6	156	82	0	131	0	651	712	75.9	50	--	--	1.09	2% O2,NO STAGING
7/16-6	7-15	0/69/31	76.2	11.4	2.1	12	160	84	0	132	.5	651	712	77.3	50	1.22	4	.92	4' STAGE HT.,LO STAGING
7/16-7	7-15	0/69/31	76.2	11.4	2.2	12.4	156	82	0	132	0	650	710	77.8	50	1.22	4	.84	MED.STAGING
7/16-8	7-15	0/69/31	76.2	11.4	2.3	11.6	157	83	0	133	0	648	707	77.1	50	1.22	4	.79	HI STAGING
7/16-1C	7-15	0/69/31	76.2	11.4	3.8	11	192	101	0	145	0	665	737	75.7	50	--	--	1.2	REPT. BASELINE
7/17-1P	7-10	0/72/28	76.2	11.4	3.7	11.6	206	108	0	187	0	663	733	76.2	90	--	--	1.2	BASELINE,PARTIC.,REG.90%
7/17-2P	7-16	0/47/53	76.2	11.4	4	11.3	219	117	0	234	.5	672	749	75.7	90	--	--	1.22	BASELINE,PARTIC.
7/17-3P	7-17	0/63/37	76.2	11.4	4.6	11.5	229	121	0	176	1	669	744	76.0	90	--	--	1.26	BASELINE,PARTIC.
7/18-1	7-16	0/47/53	76.2	11.4	4	11	221	118	0	232	1	674	754	75.0	50	--	--	1.22	BASELINE,REG.50% OPEN
7/18-2	7-16	0/46/54	76.2	11.4	1.9	13.4	160	86	0	228	3.5	653	715	78.4	50	--	--	1.09	2% O2,NO STAGING
7/18-3	7-16	0/47/53	76.2	11.4	2.1	13.3	177	95	0	219	--	654	717	78.4	90	1.22	4	.92	LO STAG.,PRI.AIR REG.50%
7/18-4	7-16	0/47/53	76.2	11.4	2.25	13.1	179	96	0	265	2	654	718	78.2	90	1.22	4	.93	LO STAG.,PRI.AIR REG.90%
7/18-5	7-16	0/47/53	76.2	11.4	2.1	13.3	172	92	0	241	2	653	715	78.5	90	1.22	4	.85	MED.STAGING
7/18-6	7-16	0/47/53	76.2	11.4	2.15	11.3	166	89	0	236	2	649	708	76.8	90	1.22	4	.79	HI STAGING

TABLE B-1. EMISSIONS SUMMARY (CONTINUED)

TEST#	DATE'80	FUEL& NG-FG/AG/#6	PROC. RATE CM/H	HEAT INPUT MW	O2 %	CO2 %	NO PPM*	NO NG/J	CO PPM*	SO2 PPM*	SMOKE SPOT	STACK T K	STACK T F	HTR EFF %	SEC.AIR REG. % OPEN	STAGE HT. M	STAGE HT. FT	BRN. STOIC RATIO	COMMENTS
7/18-7	7-16	0/47/53	76.2	11.4	1.9	12.9	179	96	0	228	3	653	715	78.2	90	--	--	1.09	2% O2, NO STAGING
7/18-8	7-16	0/47/53	76.2	11.4	4.1	11.5	219	117	0	233	.5	672	749	76.0	90	--	--	1.23	BASELINE, SEC.REG.90% OPN
7/19-1	7-18	0/42/58	76.2	11.4	4.1	10.9	234	125	0	207	2.25	668	742	75.3	90	--	--	1.22	BASELINE
7/19-1P	7-18	0/46/54	76.2	11.4	2.3	12	176	94	0	195	2.25	652	713	77.4	90	1.22	4	.8	OPTIMUM LO-NOX, PARTIC.
7/19-2	7-21	0/47/53	76.2	11.4	3.8	11.7	224	120	0	248	1	671	747	75.7	90	--	--	1.21	BASELINE
7/19-2P	7-21	0/46/54	76.2	11.4	2.1	12.8	171	91	0	225	6	647	704	77.9	90	1.22	4	.79	OPTIMUM LO-NOX, PARTIC.
7/19-3	7-21	0/47/53	76.2	11.4	4.1	9.2	227	121	0	186	--	673	752	72.4	90	--	--	1.22	BASELINE
7/19-3P	7-21	0/46/54	76.2	11.4	2.3	12.8	182	97	0	201	3.25	653	715	77.9	90	1.22	4	.8	OPTIMUM LO-NOX, PARTIC.

& FUEL GIVEN AS PERCENTAGES OF NATURAL GAS-FUEL GAS (NG-FG), ADSORBER GAS (AG), AND NO.6 OIL

* DRY BASIS, CORRECTED TO 3% O2

TABLE B-1. EMISSIONS SUMMARY (CONTINUED) Set 2

TEST#	DATE '81	FUEL& NG-FG/AG/ NO.6	PROC. RATE CM/H	HEAT INPUT MW	O2 %	NO PPM*	NO NG/J	NOX PPM*	NOX NG/J	CO PPM*	SO2 PPM*	STACK K	STACK T F	HTR EFF %	SEC. AIR REG. %OPEN	STAGE HT. M	STAGE HT. FT	BRN. STOIC RATIO	KG STM INJ PER KG FUEL	COMMENTS
1-1.	3-31	0/78/22	72.2	11,5	4.8	170	88.7	177	92.4	0	58	639	691	--	40	--	--	--	--	AS FOUND,3 OIL GUNS ON
1-2	4-1	0/67/33	72.2	11.5	5.8	199	105	206	109	0	61	664	735	--	40	--	--	--	--	AS FOUND,6 OIL GUNS ON
1-3	4-1	0/64/36	72.2	11.5	5.8	204	108	204	108	0	91	661	729	--	40	--	--	--	--	AS FOUND,6 OIL GUNS ON
1-4	4-1	0/100/0	72.2	11.5	5.6	82	41.9	82	41.9	0	0	665	737	--	40	--	--	--	1	AS FOUND,ATOM.STM.ON
1-5	4-2	0/75/25	72.9	11.5	6	198	104	205	107	0	54	668	743	73.5	40	--	--	--	--	AS FOUND,5 OIL GUNS ON
2-1	4-2	0/72/28	72.9	11.5	5.5	215	113	218	118	0	167	672	750	74.3	40	--	--	--	--	AS FOUND,HI O2,6 GUNS
2-2	4-2	0/69/31	72.9	11.5	4.4	222	117	224	118	0	141	653	716	75.7	40	--	--	--	--	BASELINE,6 OIL GUNS ON
2-3	4-2	0/72/28	72.2	11.5	2.2	185	97.1	191	100	0	--	640	692	77.6	40	--	--	--	--	LO O2,6 OIL GUNS ON
2-4	4-2	0/69/31	72.2	11.5	.5	143	75.3	161	84.8	145	147	629	673	79.0	40	--	--	--	--	CO LIM.,6 OIL GUNS ON
3-1	4-3	0/100/0	90.8	14.5	3	115	58.8	115	58.8	0	0	696	793	74.9	100	--	--	--	--	GAS BASELINE
3-2	4-3	0/56/44	90.8	14.5	2.9	164	87.4	164	87.4	0	204	686	774	76.3	100	--	--	--	--	GAS-OIL BASELINE
3-3	4-6	0/52/48	90.8	14.5	3.2	215	115	219	117	0	282	691	784	76.2	100	--	--	--	--	GAS-OIL BASELINE
3-4	4-6	0/47/53	90.8	14.5	1.9	174	93.6	180	96.8	0	285	676	757	77.7	100	--	--	--	--	LO O2
3-5	4-6	0/47/53	90.8	14.5	.35	121	65.1	127	68.3	466	195	656	720	79.4	100	--	--	--	--	CO LIM.
4-1	4-7	0/47/53	91.2	14.5	2.5	198	107	207	111	0	406	684	772	77.0	100	--	--	--	--	BASELINE
4-2	4-7	0/50/50	91.2	14.5	2.7	202	108	208	112	0	466	685	773	76.7	100	0	0	--	--	NAT.DRAFT STAGING
4-3	4-7	0/52/48	91.2	14.5	3	186	99.6	186	99.6	0	461	688	778	76.3	60	0	0	--	--	NAT.DFT.STAG.,REG.ADJ.
4-4	4-7	0/50/50	91.2	14.5	2.8	164	88	164	88	0	365	684	771	76.4	30	0	0	--	--	NAT.DFT.STAG.,REG.ADJ.
4-5	4-7	0/52/48	91.2	14.5	2.8	218	117	228	122	0	343	687	776	76.6	100	--	--	--	--	BASELINE
5-1	4-8	0/100/0	72.2	15.9	2.9	112	57.2	115	58.8	0	23	706	811	71.6	100	--	--	--	.5	MAX.STM.THRU OIL TIPS
5-2	4-8	0/100/0	72.2	13.7	1.7	105	53.7	112	57.2	0	0	678	761	73.5	100	--	--	--	.5	MAX.STM.INJ.,LO O2
5-3	4-8	0/100/0	72.2	13.4	1.85	104	53.1	112	57.2	0	65	678	761	75.3	100	--	--	--	.2	MIN.STM.INJ.,LO O2
5-4	4-8	0/100/0	72.2	13.4	1.8	108	55.2	112	57.2	0	0	675	755	76.6	100	--	--	--	0	LO O2,NO STM.
5-5	4-8	0/100/0	72.2	13.7	2.3	116	59.3	116	59.3	0	0	687	776	75.8	100	--	--	--	0	2.3% O2,NO STM.
5-6	4-8	0/100/0	72.2	13.7	2.6	120	61.3	120	61.3	0	0	687	776	75.6	100	--	--	--	0	BASELINE
5-7	4-8	0/100/0	72.2	13.9	3	115	58.8	117	59.8	0	23	689	780	74	100	--	--	--	.2	MIN.STM.INJ.,NORMAL O2
5-8	4-8	0/100/0	72.2	13.7	3.1	70	35.8	70	35.8	0	29	688	778	75.3	30	0	0	--	0	NAT.DFT.STAG.,REG.ADJ.
6-1	4-20	0/47/53	73.4	11	3.8	243	131	243	131	10	293	644	700	77.1	100	--	--	1.2	--	BASELINE
6-2	4-20	0/47/53	73.4	11	4	215	116	215	116	11	218	641	693	77.3	100	1.2	4	.92	--	STAGED COMB.AIR (SCA)
6-3	4-21	0/50/50	78.3	13.2	3.7	203	109	203	109	10	232	655	719	78.3	33	--	--	1.2	--	NEW BASELINE
6-4	4-21	0/55/45	78.3	13.2	3.9	197	105	197	105	11	217	661	729	76.2	33	1.2	4	.99	--	LO SCA
6-5	4-21	0/53/47	78.3	13.2	3.7	188	101	--	--	10	220	654	717	76.6	33	1.2	4	.92	--	MED. SCA
6-6	4-21	0/53/47	78.3	13.2	3.8	172	92	172	92	10	227	630	674	77.6	25	1.2	4	.81	--	HI SCA,REG.ADJ.
6-7	4-21	0/50/50	78.3	13.2	3.9	165	88.4	165	88.4	11	259	630	674	79.2	10	1.2	4	.79	--	MAX.SCA,REG.ADJ.
6-8	4-21	0/53/47	78.3	13.2	3.6	167	89.3	167	89.3	10	213	643	698	77.1	10	1.2	4	.8	--	MAX.SCA,REG.ADJ.,AIR INJ.45 DEG.OFF RADIAL
6-9	4-21	0/50/50	78.3	13.2	3.6	153	82.1	153	82.1	10	213	646	703	78.6	10	1.2	4	.78	--	MAX.SCA,REG.ADJ.,AIR INJ. TANGENTIALLY
6-10	4-21	0/50/50	78.3	13.2	3.7	140	75.1	140	75.1	10	214	646	703	78.6	10	1.2	4	.78	--	MAX.SCA,REG.ADJ.,AIR INJ.RADIALLY OUTWARD
6-11	4-21	0/50/50	78.3	13.2	3.9	212	114	212	114	11	217	658	725	78.2	33	--	--	1.21	--	REPEAT BASELINE
7-1	4-22	0/50/50	78.3	13.1	4.1	214	115	214	115	11	256	662	732	76.0	33	--	--	1.22	--	BASELINE
7-2	4-22	0/50/50	78.3	13.1	1.8	155	83.1	155	83.1	19	245	642	696	78.3	33	--	--	1.09	--	LO O2
7-3	4-22	0/50/50	78.3	13.1	1.7	145	77.8	145	77.8	19	239	643	698	78.5	33	1.2	4	.9	--	LO O2,LO SCA
7-4	4-22	0/53/47	73.4	10.2	1.8	110	58.8	11	58.5	27	267	618	652	79.3	10	1.2	4	.7	--	LO O2,MED.SCA,REG.ADJ.
7-5	4-22	0/50/50	73.4	10.2	1.9	101	54.2	101	54.2	19	318	606	630	79.9	10	1.2	4	.6	--	LO O2,MAX.SCA,REG.ADJ. LANCES NORMAL
7-6	4-22	0/45/55	73.4	12	4	220	119	220	119	11	284	646	703	77.1	33	--	--	1.22	--	REPEAT BASELINE
8-1	4-23	0/54/46	73.4	11.3	4	226	121	226	121	11	278	649	709	77.3	33	--	--	1.22	--	BASELINE
8-1P	4-23	0/50/50	73.4	11.3	1.9	90	48.3	101	54.2	19	241	636	685	79.1	10	1.2	4	.66	--	OPTIMUM LOW-NOX,PARTICULATES

& FUEL GIVEN AS PERCENTAGES OF NATURAL GAS-FUEL GAS (NG-FG), ADSORBER GAS (AC), AND NO.6 OIL BY HEAT INPUT

* DRY BASIS, CORRECTED TO 3% O2

APPENDIX C

CONTINUOUS MONITOR CERTIFICATION DATA SHEETS

APPENDIX C

The results of the second laboratory's PDSA analysis of the midrange NO calibration gas which was used during the continuous monitor relative accuracy tests are presented below. These measurements were taken after the first relative accuracy test, but before the second. The results from the first laboratory's PDSA analysis were apparantly in error during the first relative accuracy test, however, their analyses appeared to be valid for the second relative accuracy test and those results were used on the following page.

Four individual grab samples using EPA Method 7 were taken. The test procedures followed the EPA recommendations for sampling a NOx calibration gas in N_2. A measured amount of ambient air was introduced to the flasks after sampling. This was done to insure that sufficient oxygen was present to complete the conversion of NO to NO_2. Results of these tests can be found in Table 1.

Table 1. NOx Results from Second Laboratory

Flask	NOx ppm dry
2	128
6	143
7	134
1	Sample Lost

KVB

Engineer TIDONA

MONITOR PERFORMANCE TEST DATA SHEET

ANALYSIS OF CALIBRATION GAS MIXTURES

NO_x Calibration Gases

Date: 5-28-81

Reference Method Used: 7

Mid-Range : 143 ppm NO, 147.5 ppm NO_x } Span Gas certifications
High-Range : 221.4 ppm NO, 226 ppm NO_x }

Mid-Range Calibration Gas Mixture

Sample 1 142 ppm
Sample 2 142 ppm
Sample 3 136 ppm
Average 140 ppm

High-Range (span) Calibration Gas Mixture

Sample 1 218 ppm
Sample 2 213 ppm
Sample 3 221 ppm
Average 217 ppm

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MONITOR PERFORMANCE TEST DATA SHEET

ACCURACY DETERMINATION (NO_x)

Engineer TIDONA

Test No.	Date and Time	Reference Method Samples				Analyzer 1-Hour Average (ppm)* NO_x dry @ 3% O_2		Difference (ppm) NO_x (Ref. - Analyzer)	
		NO_x Sample 1 (ppm) dry @ 3% O_2	NO_x Sample 2 (ppm) dry @ 3% O_2	NO_x Sample 3 (ppm) dry @ 3% O_2	NO_x Sample Average (ppm) dry @ 3% O_2				
1	5-28-81 07:30	51	51	47	50		50		0
2	5-28-81 08:30	49	49	41	46		48		-2
3	5-28-81 09:30	49	—	53	51		50		+1
4	5-28-81 10:30	52	46	46	48		51		-3
5	5-28-81 11:30	46	51	51	49		54		-5
6	5-28-81 12:30	53	48	50	50		52		-2
7	5-28-81 13:30	46	49	46	47		51		-4
8	5-28-81 14:30	50	38	40	43		51		-8
9	5-28-81 15:30	44	43	42	43		50		-7

Mean reference method test value (NO_x) 47

Mean of the differences (Absolute Value) 3.3

95% Confidence intervals = ± 2.3 ppm (NO_x)

Accuracies = $\frac{\text{Mean of the differences + 95\% confidence interval}}{\text{Mean reference method value}}$ x 100 = 11.9 % (NO_x)

* Explain and report method used to determine integrated averages

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KVB

~~Engineer~~ PIONESSA Jr

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

NO INSTRUMENT

143 ppm SPAN GAS

TIME	Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)	
12:00	4/30/81	0.00 ppm	—	144 ppm	—	
12:00	5/1/81	-0.65 ppm	-0.65	145 ppm	+ 1 ppm	
12:00	5/2/81	-1.00 ppm	-1.00	134 ppm	- 10 ppm	
12:00	5/3/81	0.00 ppm	0.00	145 ppm	+ 1 ppm	
12:00	5/4/81	0.00 ppm	0.00	146 ppm	+ 2 ppm	
	5/5/81	+0.25 ppm	+0.25	144 ppm	+ 1 ppm	
	5/6/81	+0.22 ppm	+0.22	149 ppm	+6 ppm	
	5-7-81	-.57	-.57	146	+ 2 ppm	
0.27	5-8-81	-0.27	0.0	144	0	(not incl. in avg.)

Zero Drift = [Mean Zero Drift* 0.25 + C.I. (Zero) 0.45]
÷ [Instrument Span] x 100 = 0.49 .

Calibration Drift = [Mean Span Drift* 0.43 + C.I. (Span) 4.56]
÷ [Instrument Span] x 100 = 2.00 .

*Absolute Value

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KVB

~~Engineer:~~ PIONESSA JR

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

O_2 INSTRUMENT

4.54% SPAN GAS

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
4-30-81 12:00	0.04%	—	4.53%	—
5-1-81 12:00	0.02%	-0.02%	4.47%	-0.06%
5-2-81 12:00	0.03%	+0.01%	4.48%	-0.06%
5-3-81 12:00	0.03%	0.00%	4.58%	-0.05%
5-4-81 12:00	0.04%	0.0%	4.61%	+0.07%
5-5-81 12:00	0.05%	+0.01%	4.62%	+0.08%
5-6-81 12:00	0.04%	+0.02%	4.56%	+0.02%
5-7-81 12:00	0.02%	0.0%	4.57%	+0.04%

Zero Drift = [Mean Zero Drift* 0.0 + C.I. (Zero) 0.009]
÷ [Instrument Span] x 100 = 0.09%.

Calibration Drift = [Mean Span Drift* 0.006 + C.I. (Span) 0.057]
÷ [Instrument Span] x 100 = 0.63%.

*Absolute Value

0-10% range

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KVB

Engineer TIDONA

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

HORIBA CO2 INST – MODEL # PIR 2000   SPAN GAS – 10.51%

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
07:00 5/14/81	0	0	10.51%	0
07:00 5-15-81	.02	+.02	10.50%	−0.01
07:00 5-16-81	−0.01	−.01	10.49%	+.02
07:00 5-17-81	+0.1	+0.1	10.53%	+.02
07:00 5-18-81	+0.1	0.0	10.52%	+.01
07:00 5-19-81	+0.1	0.0	10.53%	+.02
07:00 5-20-81	+0.08	+0.08	10.60%	+.09
07:00 5-21-81	−0.03	−0.03	10.60%	+.09

Zero Drift = [Mean Zero Drift* 0.023 + C.I. (Zero) 0.045]
÷ [Instrument Span] x 100 = 0.27%.

Calibration Drift = [Mean Span Drift* 0.034 + C.I. (Span) 0.037]
÷ [Instrument Span] x 100 = 0.28%.

*Absolute Value

RANGE 3 = 0–25%.

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~~Engineer~~ PIONESSA JR

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

CO INSTRUMENT

297 ppm SPAN GAS

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
4-30-81 12:00	0.0 ppm	—	298 ppm	—
5-1-81 12:00	+7.5 ppm	+7.5 ppm	312 ppm	+15 ppm
5-2-81 12:00	-5.0 ppm	-12.5 ppm	310 ppm	+13 ppm
5-3-81 12:00	-2.0 ppm	+3.0 ppm	293 ppm	-4 ppm
5-4-81 12:00	+1.0 ppm	+1.0 ppm	296 ppm	-1 ppm
5-5-81 12:00	+4.0 ppm	+4.0 ppm	298 ppm	+1 ppm
5-6-81 12:00	+2.0 ppm	+2.0 ppm	299 ppm	+2 ppm
5-7-81 12:10	-2.0 ppm	-2.0 ppm	298 ppm	+1 ppm

Zero Drift = [Mean Zero Drift* 0.4 + C.I. (Zero) 5.9]
÷ [Instrument Span] x 100 = 0.32%.

Calibration Drift = [Mean Span Drift* 3.9 + C.I. (Span) 6.7]
÷ [Instrument Span] x 100 = 0.53%.

*Absolute Value

0-2000 ppm range

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NO ANALYZER

MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

143 ppm Span gas

Data Set No.	Time 4-30-81 Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1 START	12:00		4-30-81	0.0 ppm	—	144 ppm		—
2 1	14:00		"	0.8 ppm	+0.8 ppm	146.7	+2.7	+1.9
3 2	16:00		"	1.60 ppm	+0.8 ppm	147.7	+1.0	+1.0
4 3	18:00		"	1.10 ppm	-0.5 ppm	145.7	-2.0	-1.5
5 4	20:00		"	0.45 ppm	-0.65	144.0	-1.7	-1.1
6 5	22:00		"	-0.50	-0.4	140.7	-3.3	-2.3
7 START	08:00		5-1-81	-1.12	—	138.5	—	—
8 6	10:00		"	-1.15	-0.03	137.7	-0.8	-0.8
9 7	12:00		"	-0.65	+0.5	142.4	+4.7	+4.2
10 START	12:30		"	0.0	—	144	—	—
11 8	14:30		"	0.35	+0.35	144.1	+0.1	+0.3
12 9	16:30		"	0.00	-0.35	142.5	-1.6	-1.3
13 10	18:30		"	-0.02	-0.02	141.6	-0.9	-0.9
14 START	08:00		5-2-81	-1.00	—	135.	—	—
15 11	10:00		"	-1.00	0.00	134.	-1.0	-1.0
16 12	12:00		"	-1.00	0.00	134.	0.0	0.0
17 START	12:30		"	0.00	—	144.	—	—
18 13	14:30		"	0.00	0.00	143.	-1.0	-1.0
19 14	16:30		"	0.20	+0.20	145.	+2.0	+1.8
20 15	18:30		"	0.10	-0.10	141.	-4.0	-3.9

Zero Drift = [Mean Zero Drift* 0.04 + CI (Zero) 0.24] ÷ [Span] x 100 = 0.11%.

Calibration Drift = [Mean Calib. ~~Span~~ Drift* 0.307 + CI (Span) 0.652] ÷ [Span] x 100 = 0.38%.

*Absolute Value.

$$C.I. = \frac{t_{.975}}{n\sqrt{n-1}}\sqrt{n(\Sigma x_i^2)-(\Sigma x_i)^2} = \frac{2.145}{15\sqrt{14}}\sqrt{15(54.68)-(23)^2} = \frac{2.145}{15\sqrt{14}}(17.06) = 0.652$$

0 - 250 ppm range

3.0 - 2HR
3.6 - 24 HR

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MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

O_2 ANALYZER

4.54% span gas

Data Set No.	4-30-81 Time Begin	End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1 START	12:00		4-30-81	0.04%	—	4.53%		—
2	14:00		"	0.04 %	0.00	4.55 %	+0.02	+.02
3	16:00		"	0.04%	0.00	4.55%	0.0	0.00
4	18:00		"	0.04%	0.00	4.55	0.0	0.00
5	20:00		"	0.04 %	0.00	4.53	-0.02	-0.02
6	22:00		"	0.04%	0.00	4.49	-0.04	-0.04
7 START	08:00		5-1-81	0.04 %	—	4.45	—	—
8	10:00		"	0.04 %	0.00	4.43	-0.02	-0.02
9	12:00		"	0.02 %	-0.02	4.46	+0.03	+0.05
10 START	12:30		"	0.02	—	4.54	—	—
11	14:30		"	0.02	0.00	4.53	-0.01	-0.01
12	16:30		"	0.02	0.00	4.52	-0.01	-0.01
13	18:30		"	0.03	+0.01	4.52	0.0	+0.01
14 START	08:00		5-2-81	0.02	—	4.48	-0.04	—
15	10:00		"	0.03	+0.01	4.49	+0.01	0.00
16	12:00		"	0.03 %	0.00	4.49	0.0	0.00
17 START	12:30		"	0.03%	—	4.54	+0.05	—
18	14:30		"	0.03%	0.00	4.52	-0.02	-0.02
19	16:30		"	0.03%	0.00	4.54	+0.02	+0.02
20	18:30		"	0.03	0.00	4.54	0.0	0.00

Zero Drift = [Mean Zero Drift* 0.0 + CI (Zero) 0.004] ÷ [Span] x 100 = 0.04%.

Calibration Drift = [Mean ~~Span~~ Calib. Drift* 0.001 + CI (Span) 0.012] ÷ [Span] x 100 = 0.12%.

*Absolute Value.

0-10% range

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.4 - 2HR
.5 - 24HR

MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

CO ANALYZER

297 ppm Span gas

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1 START	12:00		4-30-81	0.0 ppm	—	298 ppm	—	—
2	14:00		"	-4.0	-4.0	283	-15	-11
3	16:00		"	+4.0 ppm	+8.0	311 ppm	+28	+20
4	18:00		"	0.0 ppm	-4.0 ppm	298.	-13	-9
5	20:00		"	+1.7	+1.7	304.	+6	+4
6	22:00		"	+5.0	-3.3	312.	+8	+5
7 START	08:00		5-1-81	+6.1	—	322.	—	—
8	10:00		"	+6.0	-0.1	324.	+2	+2
9	12:00		"	+7.5	+1.5	321.	-3	-5
10 START	12:30		"	0.0	—	296	—	—
11	14:30		"	-4.1	-4.1	294	-2	-4
12	16:30		"	-5.5	-1.1	294	0	-1.4
13	18:30		"	-9.4	-3.9	292	-2	-1.9
14 START	08:00		5-2-81	-4.0	—	303.	+11	—
15	10:00		"	-4.0	0.0	310.	+7	+7.0
16	12:00			-5.0	-0.1	308.	-2	-1.0
17 START	12:30		"	0.0	—	296	-12	—
18	14:30		"	-1.0	-1.0	303	+7	+8.0
19	16:30		"	0.00	+1.0	311	+8	+7.0
20	18:30		"	0.00	-1.0	307	-4	-4.0

Zero Drift = [Mean Zero Drift* 0.7 + CI (Zero) 1.8] ÷ [Span] x 100 = 0.13%.

Calibration Drift = [Mean ~~Span~~ Calib. Drift* 1.0 + CI (Span) 4.3] ÷ [Span] x 100 = 0.27%.

*Absolute Value.

0- 2000 ppm range

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MODEL – PIR 2000

PIONEER-JR

HORIBA CO2 INSTRUMENT

MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

SPAN GAS = 10.51%

0.0330

Data Set No.	Time		Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
	Begin	End						
1	07:00		5-14-81	0.0	—	10.51%	—	—
2 1	09:00			0.0	0.0	10.52	+0.01	+0.01
3 2	11:00			0.0	0.0	10.50%	−0.02	−0.02
4 3	13:00			0.0	0.0	10.51	+0.01	+0.01
5 4	15:00			0.0	0.0	10.50	−0.01	−0.01
6 5	17:00			0.0	0.0	10.51	+0.01	+0.01
7 6	19:00			0.0	0.0	10.51	0.00	0.0
8 7	21:00			0.01	+0.01	10.50	−0.01	−0.02
9 8	23:00			0.01	0.00	10.50	0.00	0.0
10 9	01:00		5-15-81	0.01	0.00	10.50	0.00	0.0
11	07:00			0.0	—	10.51	—	—
12 10	09:00			0.00	0.00	10.53	+0.02	+0.02
13 11	11:00			0.00	0.00	10.51	−0.02	−0.02
14 12	13:00			0.00	0.00	10.50	−0.01	−0.01
15 13	15:00			0.00	0.00	10.50	0.00	0.0
16 14	17:00			0.00	0.00	10.51	+0.01	+0.01
17 15	19:00			0.00	0.00	10.51	0.00	0.0
18								
19								
20								

Zero Drift = [Mean Zero Drift* 0.00 + CI (Zero) 0.00] ÷ [Span] x 100 = 0.00%

Calibration Drift = [Mean Span Drift* 0.001 + CI (Span) 0.001] ÷ [Span] x 100 = 0.00%

*Absolute Value.

Range 0-25%

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Figure B-8.

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5-13-81

MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

TECO NO INST. - MODEL 10 RANGE 0-250 ppm

Calibration Gas Mixture Data

Mid (50%) 143 ppm High (90%) 222 ppm

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences[1], ppm
1 O	0	0.0	0.0
2 M	143	142	+1
3 O	0	0.0	0
4 H	222	223	-1
5 M	143	142	+1
6 H	222	222	0
7 M	143	142	+1
8 O	0	0.0	0
9 M	143	141	+2
10 O	0	0.0	0
11 H	222	222	0
12 M	143	142	+1
13 H	222	222	0
14 O	0	0.0	0
15 H	222	222	0

	Mid	High
Mean difference	1.2	-0.2
Confidence interval	+ 0.6	+ 0.6
Calibration error = $\frac{\text{Mean Difference}^{2} + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	1.3 %	0.4 %

---

[1] Calibration gas concentration - measurement system reading

[2] Absolute value

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KVB11-6015-1224

Figure B-8.

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MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

O_2 INST

RANGE 0-10%

Calibration Gas Mixture Data

Mid (50%) 4.54 [redacted]

High (90%) 9.00% [redacted]

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences[1], ppm
1 0	0	0	0
2 M	4.54%	4.54%	0
3 0	0	0	0
4 H	9%	8.96 %	-0.04
5 M	4.54%	4.60 %	+0.06
6 H	9%	8.89 %	-.11
7 M	4.54 %	4.60 %	+0.06
8 0	0	0	0
9 M	4.54%	4.58 %	+0.04
10 0	0	0	0
11 H	9%	8.93 %	-.07
12 M	4.54%	4.58 %	+.04
13 H	9%	8.87%	-.13
14 0	0	0	0
15 H	9%	8.90 %	-.10

	Mid	High
Mean difference	0.04	0.09
Confidence interval	±0.03	± 0.04

Calibration error = $\frac{\text{Mean Difference}^2 + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$ Mid 1.54 % High 1.44 %

---

[1] Calibration gas concentration - measurement system reading

[2] Absolute value

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KVB11-6015-1224

Figure B-8.

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MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

HORIBA CO_2 INST MODEL # PIR 2000 RANGE 3 = 0-25%

Calibration Gas Mixture Data

Mid (50%) 10.51% [redacted] High (90%) 18.00% [redacted]

Run #	Calibration Gas Concentration, [redacted] %	Measurement System Reading, [redacted] %	Differences[1], [redacted] %
1 0	0	0	0
2 M	10.51	10.55	+0.04
3 0	0	0	0
4 H	18.00	17.98	-0.02
5 M	10.51	10.62	+0.11
6 H	18.00	17.85	-0.15
7 M	10.51	10.63	+0.12
8 0	0	-0.02	-0.02
9 M	10.51	10.68	+0.17
10 0	0	-0.02	-0.02
11 H	18.00	17.94	-0.06
12 M	10.51	10.60	+0.09
13 H	18.00	17.93	-0.07
14 0	0	-0.02	-0.02
15 H	18.00	17.92	-0.08

	Mid	High
Mean difference	0.11	0.08
Confidence interval	+ 0.06	+ 0.06
Calibration error = $\frac{\text{Mean Difference}^{2} + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	1.62 %	0.78 %

---

[1] Calibration gas concentration - measurement system reading

[2] Absolute value

5/21/81

Figure B-8.

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Engineer Gabriel

MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

Calibration Gas Mixture Data

Mid (50%) 988 ppm High (90%) 1790 ppm

BECKMAN MODEL 865 - CO ANALYZER

Run #		Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences[1], ppm
1	0	0	0	0
2	M	988	988	0
3	0	0	0	0
4	H	1790	1780	-10.
5	M	988	992	+4.
6	H	1790	1785	-5.
7	M	988	988	0.
8	0	0	-2.	-2.
9	M	988	990	+2.
10	0	0	-1.	-1.
11	H	1790	1798	+8
12	M	988	984	-4.
13	H	1790	1786	-4.
14	0	0	+1	+1
15	H	1790	1800	+10

780

-10

10

READING ON RANGE 0 - 2000 ppm

	Mid	High
Mean difference	0.4	-0.2
Confidence interval	±3.7	±10.8
Calibration error = $\frac{\text{Mean Difference}^{2} + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	0.4 %	0.6 %

---

[1] Calibration gas concentration - measurement system reading

[2] Absolute value

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME FOR CONTINUOUS INSTRUMENTS

TELEDYNE MODEL 326 A O_2 ANALYZER

Date of Test 4-29-81

Span Gas Concentration 4.54 ~~ppm~~ %

Analyzer Span Setting 4.54 ~~ppm~~ %

Upscale
1 33 seconds
2 35 seconds
3 35 seconds

Average upscale response 34 seconds

Downscale
1 37 seconds
2 36 seconds
3 37 seconds

Average downscale response 37 seconds.

System average response time (slower time) = 37 seconds.

$$\%\ \text{deviation from slower system average response} = \left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% = 8.1.$$

upscale 4.31 = 95% of span
downscale 0.23

ZERO REG PRESSURE 12 psi
REG PRESSURE 10 PSI (LO CO O_2)
SAMPLE PRESSURE 7 PSI

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME FOR CONTINUOUS INSTRUMENTS

TECO NO-NOX INSTRUMENT MODEL #10A

Date of Test 4-29-81

Span Gas Concentration 143 ppm

Analyzer Span Setting 143 ppm

Upscale
1 13.0 seconds
2 9.5 seconds
3 9.0 seconds

Average upscale response 10.5 seconds

Downscale
1 11.0 seconds
2 10.5 seconds
3 9.0 seconds

Average downscale response 10.2 seconds.

System average response time (slower time) = 10.5 seconds.

$$\%\ \text{deviation from slower system average response} = \left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% = 2.86.$$

7ppm – 95% DOWNSCALE
137PPm – 95% UPSCALE
ZERO REG PRESSURE = 10psi
NO-NOx SPAN GAS PRESSURE - 10psi
SAMPLE PRESS - 10psi

Data Sheet 6017-35
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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME FOR CONTINUOUS INSTRUMENTS

HORIBA CO2 INST — MODEL PIR 2000 CAL GAS 10.51%

Date of Test 5-13-81

Span Gas Concentration 10.51 % ~~ppm~~

Analyzer Span Setting 42% OF SCALE ~~ppm~~ 0-100

Upscale	1	14 seconds
	2	16 seconds
	3	15 seconds

Average upscale response 15 seconds

Downscale	1	15 seconds
	2	16 seconds
	3	15 seconds

Average downscale response 15 seconds.

System average response time (slower time) = 15 seconds.

$$\text{\% deviation from slower system average response} = \left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% = 0.0.$$

REGULATOR PRESS — 10psi RANGE 3 @ 0 – 25%

SAMPLE PRESS — 10psi

SCFH — 2.0

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME FOR CONTINUOUS INSTRUMENTS

BECKMAN MODEL 865 CO ANALYZER

Date of Test 4-29-81

Span Gas Concentration 297 **ppm**

Analyzer Span Setting 297 **ppm**

Upscale

1 30 **seconds**

2 26 **seconds**

3 31 **seconds**

Average upscale response 29 **seconds**

Downscale

1 25.5 **seconds**

2 24 **seconds**

3 22.5 **seconds**

Average downscale response 24 **seconds.**

System average response time (slower time) = 29 **seconds.**

$$\text{\% deviation from slower system average response} = \left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% = 17.2.$$

upscale: 282 ppm = 95% of span

downscale: 15 ppm

reg. press 10 psi

Sample press 7 psi

reg. press. zero gas - 12 psi

Data Sheet 6017-35
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APPENDIX D

TABULATION OF 15-MINUTE AVERAGES

PETROLEUM PROCESS HEATER WITH STAGED COMBUSTION AIR

APPENDIX D

This appendix includes the computer printout sheets for the 15-minute averages for the extended duration test of a petroleum process heater modified to incorporate staged combustion air. These data were recorded on an automatic data logger and transcribed onto sheets which were keypunched for input to the KVB data analysis program. Presented in this appendix are the 15-minute averages for each day. These averages were then compiled into 24-hour averages for the entire test period.

KVB TESTING CODES A THROUGH K

Code	Explanation
A	Testing Begins
B	Testing Ends
C	Instrument Calibrations
D	NO Instrument Out of Service (maintenance)
E	O_2 Instrument Out of Service (maintenance)
F	CO_2 Instrument Out of Service (maintenance)
G	CO Instrument Out of Service (maintenance)
H	Boiler (or unit) Out of Service
I	Continuous Monitor
J	Continuous Monitor Out of Service (maintenance)
K	Power Failure

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
5/ 1/81	930	10717.0	2.3	11.9	15	34	14	32	4	17	A
5/ 1/81	945	10717.0	1.8	12.2	16	30	14	28	4	15	
5/ 1/81	1000	10717.0	1.5	12.4	15	28	13	25	4	14	
5/ 1/81	1015	10717.0	1.9	12.1	12	51	11	48	3	26	
5/ 1/81	1030	10717.0	1.1	12.6	17	25	15	22	5	12	
5/ 1/81	1045	10717.0	1.2	12.6	16	26	14	23	4	12	
5/ 1/81	1100	10717.0	1.2	12.6	16	26	14	23	4	12	
5/ 1/81	1115	10717.0	1.0	12.7	17	25	15	22	5	12	
5/ 1/81	1130	10717.0	1.0	12.7	17	25	15	22	5	12	
5/ 1/81	1145	10717.0	.9	12.8	20	25	17	22	5	12	
5/ 1/81	1200	10717.0	1.3	12.5	16	29	14	26	4	14	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
24 HOUR DATA
DRY STACK GAS CONCENTRATION

DATE	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
5/ 1/81	10717.0	1.6	12.3	8	5	7	32	2	17
5/ 2/81	10717.0	2.1	12.0	11	43	10	40	3	22
5/ 3/81	10717.0	2.3	11.9	11	45	10	43	3	23
5/ 4/81	10717.0	2.2	11.9	13	44	12	42	4	22
5/ 5/81	10717.0	2.3	11.9	28	42	26	40	8	21
5/ 6/81	10717.0	2.5	11.7	9	44	8	42	2	23
5/ 7/81	10717.0	2.7	11.6	28	43	27	42	9	22
5/ 8/81	10717.0	2.2	11.9	6	39	5	37	1	20
5/ 9/81	10717.0	1.9	11.8	13	36	12	33	4	18
5/10/81	10717.0	1.6	12.3	13	32	12	29	3	16
5/11/81	11178.7	1.6	12.3	43	32	39	29	13	16
5/12/81	10717.0	1.4	12.4	9	30	8	27	2	14
5/13/81	10717.0	1.7	12.2	5	32	4	29	1	16
5/14/81	10717.0	1.6	12.2	12	33	11	30	3	16
5/15/81	10717.0	1.6	12.1	12	32	11	29	3	16
5/16/81	10717.0	3.9	10.5	70	55	73	57	24	31
5/17/81	10717.0	6.8	8.9	7	79	8	100	2	54
5/18/81	10717.0	3.6	10.8	209	48	216	49	71	26
5/19/81	10717.0	3.3	10.8	95	49	96	49	31	27
5/20/81	10717.0	1.6	11.9	55	31	51	28	16	15
5/21/81	10717.0	2.4	11.7	11	36	10	34	3	18
5/22/81	10717.0	2.5	11.7	48	36	46	34	15	18
5/23/81	10717.0	4.4	10.5	20	50	21	54	7	29
5/24/81	10717.0	2.1	12.0	20	43	19	41	6	22
5/25/81	10717.0	3.3	11.3	98	43	99	43	32	23
5/26/81	10717.0	4.2	10.7	7	45	7	48	2	26
5/27/81	10717.0	4.2	10.6	8	45	8	48	2	26
5/28/81	10717.0	4.1	10.4	5	46	5	49	1	26
5/29/81	10717.0	3.8	10.8	10	51	10	53	3	28
5/30/81	10717.0	3.9	10.8	13	49	13	51	4	27
5/31/81	10717.0	3.9	10.8	12	45	12	47	4	25
6/ 1/81	10717.0	3.7	10.8	8	45	8	46	2	25
6/ 2/81	10717.0	3.9	10.6	6	46	6	48	2	26

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 1/81	1215	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 1/81	1230	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 1/81	1245	10717.0	1.7	12.3	2	35	1	32	0	17	
5/ 1/81	1300	10717.0	1.7	12.3	2	35	1	32	0	17	
5/ 1/81	1315	10717.0	1.7	12.3	2	35	1	32	0	17	
5/ 1/81	1330	10717.0	1.6	12.3	2	34	1	31	0	17	
5/ 1/81	1345	10717.0	1.6	12.3	2	34	1	31	0	17	
5/ 1/81	1400	10717.0	1.6	12.3	2	34	1	31	0	17	
5/ 1/81	1415	10717.0	2.0	12.0	3	52	2	49	0	26	
5/ 1/81	1430	10717.0	1.7	12.3	2	35	1	32	0	17	
5/ 1/81	1445	10717.0	1.8	12.2	2	36	1	33	0	18	
5/ 1/81	1500	10717.0	1.7	12.3	1	35	0	32	0	17	
5/ 1/81	1515	10717.0	1.6	12.3	0	34	0	31	0	17	
5/ 1/81	1530	10717.0	1.7	12.3	0	35	0	32	0	17	
5/ 1/81	1545	10717.0	1.6	12.3	0	34	0	31	0	17	
5/ 1/81	1600	10717.0	1.5	12.4	0	33	0	30	0	16	
5/ 1/81	1615	10717.0	1.7	12.3	0	34	0	31	0	17	
5/ 1/81	1630	10717.0	1.5	12.4	0	32	0	29	0	16	
5/ 1/81	1645	10717.0	2.1	12.0	0	58	0	55	0	29	
5/ 1/81	1700	10717.0	1.6	12.3	3	35	2	32	0	17	
5/ 1/81	1715	10717.0	1.6	12.3	3	35	2	32	0	17	
5/ 1/81	1730	10717.0	1.6	12.3	3	35	2	32	0	17	
5/ 1/81	1745	10717.0	1.6	12.3	3	35	2	32	0	17	
5/ 1/81	1800	10717.0	1.6	12.3	3	35	2	32	0	17	
5/ 1/81	1815	10717.0	1.7	12.3	2	36	1	33	0	18	
5/ 1/81	1830	10717.0	1.7	12.3	0	36	0	33	0	18	
5/ 1/81	1845	10717.0	1.8	12.2	0	69	0	64	0	35	
5/ 1/81	1900	10717.0	.0	.0	3	34	2	29	0	15	E
5/ 1/81	1915	10717.0	.0	.0	4	34	3	29	1	15	E
5/ 1/81	1930	10717.0	.0	.0	4	35	3	29	1	16	E
5/ 1/81	1945	10717.0	.0	.0	3	35	2	29	0	16	E
5/ 1/81	2000	10717.0	.0	.0	5	35	4	29	1	16	E
5/ 1/81	2015	10717.0	.0	.0	6	35	5	29	1	16	E
5/ 1/81	2030	10717.0	.0	.0	8	36	6	30	2	16	E
5/ 1/81	2045	10717.0	.0	.0	8	36	6	30	2	16	E
5/ 1/81	2100	10717.0	.0	.0	9	36	7	30	2	16	E
5/ 1/81	2115	10717.0	.0	.0	10	38	8	32	2	17	E
5/ 1/81	2130	10717.0	.0	.0	10	40	8	34	2	18	E
5/ 1/81	2145	10717.0	.0	.0	11	39	9	33	3	18	E
5/ 1/81	2200	10717.0	.0	.0	9	39	7	33	2	18	E
5/ 1/81	2215	10717.0	.0	.0	8	39	6	33	2	18	E
5/ 1/81	2230	10717.0	.0	.0	7	38	5	32	1	17	E
5/ 1/81	2245	10717.0	.0	.0	6	39	5	33	1	18	E
5/ 1/81	2300	10717.0	.0	.0	9	40	7	34	2	18	E
5/ 1/81	2315	10717.0	.0	.0	11	39	9	33	3	18	E
5/ 1/81	2330	10717.0	.0	.0	10	39	8	33	2	18	E
5/ 1/81	2345	10717.0	.0	.0	9	40	7	34	2	18	E
5/ 1/81	2400	10717.0	.0	.0	9	40	7	34	2	18	E

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 2/81	15	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	30	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	45	10717.0	.0	.0	0	39	0	33	0	18	E
5/ 2/81	100	10717.0	.0	.0	0	39	0	33	0	18	E
5/ 2/81	115	10717.0	.0	.0	0	38	0	32	0	17	E
5/ 2/81	130	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	145	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	200	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	215	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	230	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	245	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	300	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	315	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	330	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	345	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	400	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	415	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	430	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	445	10717.0	.0	.0	0	40	0	34	0	18	E
5/ 2/81	500	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	515	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	530	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	545	10717.0	.0	.0	0	41	0	35	0	19	E
5/ 2/81	600	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	615	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	630	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	645	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	700	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	715	10717.0	.0	.0	0	43	0	36	0	19	E
5/ 2/81	730	10717.0	.0	.0	0	44	0	37	0	20	E
5/ 2/81	745	10717.0	.0	.0	0	42	0	35	0	19	E
5/ 2/81	800	10717.0	.9	12.8	0	42	0	37	0	20	
5/ 2/81	815	10717.0	2.3	11.9	0	43	0	41	0	22	
5/ 2/81	830	10717.0	2.5	11.7	0	44	0	42	0	23	
5/ 2/81	845	10717.0	1.5	12.4	10	36	9	33	3	18	
5/ 2/81	900	10717.0	2.1	12.0	10	42	9	39	3	21	
5/ 2/81	915	10717.0	2.0	12.0	5	41	4	38	1	21	
5/ 2/81	930	10717.0	1.9	12.1	5	41	4	38	1	20	
5/ 2/81	945	10717.0	1.9	12.1	4	41	3	38	1	20	
5/ 2/81	1000	10717.0	2.0	12.0	5	40	4	37	1	20	
5/ 2/81	1015	10717.0	2.2	11.9	105	58	100	55	33	30	
5/ 2/81	1030	10717.0	2.1	12.0	9	39	8	37	2	20	
5/ 2/81	1045	10717.0	2.1	12.0	5	42	4	39	1	21	
5/ 2/81	1100	10717.0	2.1	12.0	2	42	1	39	0	21	
5/ 2/81	1115	10717.0	2.2	11.9	3	43	2	41	0	22	
5/ 2/81	1130	10717.0	2.1	12.0	3	43	2	40	0	22	
5/ 2/81	1145	10717.0	2.2	11.9	3	43	2	41	0	22	
5/ 2/81	1200	10717.0	2.1	12.0	3	43	2	40	0	22	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 2/81	1215	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 2/81	1230	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 2/81	1245	10717.0	2.1	12.0	6	47	5	44	1	24	
5/ 2/81	1300	10717.0	2.1	12.0	5	48	4	45	1	24	
5/ 2/81	1315	10717.0	2.1	12.0	5	48	4	45	1	24	
5/ 2/81	1330	10717.0	2.0	12.0	5	46	4	43	1	23	
5/ 2/81	1345	10717.0	2.1	12.0	5	47	4	44	1	24	
5/ 2/81	1400	10717.0	2.1	12.0	5	45	4	42	1	23	
5/ 2/81	1415	10717.0	2.0	12.0	5	46	4	43	1	23	
5/ 2/81	1430	10717.0	2.0	12.0	5	44	4	41	1	22	
5/ 2/81	1445	10717.0	2.3	11.9	80	71	76	68	25	37	
5/ 2/81	1500	10717.0	2.1	12.0	5	43	4	40	1	22	
5/ 2/81	1515	10717.0	2.0	12.0	5	41	4	38	1	21	
5/ 2/81	1530	10717.0	2.0	12.0	5	41	4	38	1	21	
5/ 2/81	1545	10717.0	2.0	12.0	6	41	5	38	1	21	
5/ 2/81	1600	10717.0	1.9	12.1	6	40	5	37	1	20	
5/ 2/81	1615	10717.0	2.0	12.0	6	40	5	37	1	20	
5/ 2/81	1630	10717.0	1.9	12.1	8	39	7	36	2	19	
5/ 2/81	1645	10717.0	2.3	11.9	103	66	99	63	32	34	
5/ 2/81	1700	10717.0	1.9	12.1	8	43	7	40	2	21	
5/ 2/81	1715	10717.0	1.8	12.1	7	43	6	40	2	21	
5/ 2/81	1730	10717.0	1.8	12.1	7	42	6	39	2	21	
5/ 2/81	1745	10717.0	1.8	12.1	6	43	5	40	1	21	
5/ 2/81	1800	10717.0	1.9	12.1	6	44	5	41	1	22	
5/ 2/81	1815	10717.0	2.0	12.0	7	43	6	40	2	22	
5/ 2/81	1830	10717.0	2.0	12.0	9	44	8	41	2	22	
5/ 2/81	1845	10717.0	2.0	12.0	8	44	7	41	2	22	
5/ 2/81	1900	10717.0	1.9	12.1	11	43	10	40	3	21	
5/ 2/81	1915	10717.0	1.9	12.1	11	44	10	41	3	22	
5/ 2/81	1930	10717.0	2.1	12.0	10	45	9	42	3	23	
5/ 2/81	1945	10717.0	2.2	12.0	9	45	8	43	2	23	
5/ 2/81	2000	10717.0	2.2	11.9	9	45	8	43	2	23	
5/ 2/81	2015	10717.0	2.1	11.9	7	44	6	41	2	22	
5/ 2/81	2030	10717.0	2.1	12.0	7	44	6	41	2	22	
5/ 2/81	2045	10717.0	2.2	11.9	7	45	6	43	2	23	
5/ 2/81	2100	10717.0	2.3	11.8	8	46	7	44	2	24	
5/ 2/81	2115	10717.0	2.3	11.8	11	46	10	44	3	24	
5/ 2/81	2130	10717.0	2.4	11.7	11	46	10	44	3	24	
5/ 2/81	2145	10717.0	2.3	11.8	10	45	9	43	3	23	
5/ 2/81	2200	10717.0	2.4	11.8	10	46	9	44	3	24	
5/ 2/81	2215	10717.0	2.3	11.9	11	47	10	45	3	24	
5/ 2/81	2230	10717.0	2.3	11.9	9	46	8	44	2	24	
5/ 2/81	2245	10717.0	2.3	11.9	9	46	8	44	2	24	
5/ 2/81	2300	10717.0	2.3	11.9	8	47	7	45	2	24	
5/ 2/81	2315	10717.0	2.3	11.9	8	46	7	44	2	24	
5/ 2/81	2330	10717.0	2.3	11.8	9	46	8	44	2	24	
5/ 2/81	2345	10717.0	2.4	11.8	10	46	9	44	3	24	
5/ 2/81	2400	10717.0	2.4	11.8	10	46	9	44	3	24	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 3/81	15	10717.0	2.5	11.7	10	45	9	43	3	23	
5/ 3/81	30	10717.0	2.6	11.7	10	44	9	43	3	23	
5/ 3/81	45	10717.0	2.5	11.7	10	44	9	42	3	23	
5/ 3/81	100	10717.0	2.5	11.7	12	45	11	43	3	23	
5/ 3/81	115	10717.0	2.6	11.7	11	45	10	44	3	23	
5/ 3/81	130	10717.0	2.6	11.7	9	45	8	44	2	23	
5/ 3/81	145	10717.0	2.6	11.7	9	45	8	44	2	23	
5/ 3/81	200	10717.0	2.6	11.7	7	45	6	44	2	23	
5/ 3/81	215	10717.0	2.5	11.7	8	45	7	43	2	23	
5/ 3/81	230	10717.0	2.4	11.8	8	46	7	44	2	24	
5/ 3/81	245	10717.0	2.6	11.7	10	46	9	44	3	24	
5/ 3/81	300	10717.0	2.6	11.7	9	46	8	44	2	24	
5/ 3/81	315	10717.0	2.8	11.5	9	49	8	48	2	26	
5/ 3/81	330	10717.0	2.7	11.6	11	48	10	47	3	25	
5/ 3/81	345	10717.0	2.7	11.6	10	47	9	46	3	25	
5/ 3/81	400	10717.0	2.6	11.7	10	46	9	44	3	24	
5/ 3/81	415	10717.0	2.5	11.7	11	46	10	44	3	24	
5/ 3/81	430	10717.0	2.4	11.8	8	45	7	43	2	23	
5/ 3/81	445	10717.0	2.6	11.7	10	46	9	44	3	24	
5/ 3/81	500	10717.0	2.6	11.7	9	46	8	44	2	24	
5/ 3/81	515	10717.0	2.6	11.7	12	46	11	44	3	24	
5/ 3/81	530	10717.0	2.6	11.7	11	47	10	45	3	24	
5/ 3/81	545	10717.0	2.7	11.6	10	47	9	46	3	25	
5/ 3/81	600	10717.0	2.7	11.6	10	47	9	46	3	25	
5/ 3/81	615	10717.0	2.7	11.6	15	46	14	45	4	24	
5/ 3/81	630	10717.0	2.7	11.6	16	46	15	45	5	24	
5/ 3/81	645	10717.0	2.7	11.6	16	46	15	45	5	24	
5/ 3/81	700	10717.0	2.8	11.5	17	47	16	46	5	25	
5/ 3/81	715	10717.0	2.7	11.6	16	47	15	46	5	25	
5/ 3/81	730	10717.0	2.7	11.6	15	48	14	47	4	25	
5/ 3/81	745	10717.0	2.7	11.6	15	48	14	47	4	25	
5/ 3/81	800	10717.0	2.7	11.6	14	47	13	46	4	25	
5/ 3/81	815	10717.0	2.6	11.7	14	46	13	44	4	24	
5/ 3/81	830	10717.0	2.4	11.8	13	47	12	45	4	24	
5/ 3/81	845	10717.0	2.3	11.9	16	47	15	45	5	24	
5/ 3/81	900	10717.0	2.4	11.8	16	47	15	45	5	24	
5/ 3/81	915	10717.0	2.5	11.7	15	46	14	44	4	24	
5/ 3/81	930	10717.0	2.5	11.7	15	45	14	43	4	23	
5/ 3/81	945	10717.0	2.3	11.9	15	45	14	43	4	23	
5/ 3/81	1000	10717.0	2.4	11.8	17	46	16	44	5	24	
5/ 3/81	1015	10717.0	2.5	11.7	17	47	16	45	5	24	
5/ 3/81	1030	10717.0	2.5	11.7	18	47	17	45	5	24	
5/ 3/81	1045	10717.0	2.4	11.8	16	48	15	46	5	25	
5/ 3/81	1100	10717.0	2.3	11.9	16	47	15	45	5	24	
5/ 3/81	1115	10717.0	2.3	11.9	15	46	14	44	4	24	
5/ 3/81	1130	10717.0	2.2	11.9	17	45	16	43	5	23	
5/ 3/81	1145	10717.0	2.0	12.0	17	46	16	43	5	23	
5/ 3/81	1200	10717.0	1.9	12.0	17	46	16	43	5	23	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 3/81	1215	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 3/81	1230	10717.0	2.5	11.7	109	59	106	57	34	31	
5/ 3/81	1245	10717.0	2.1	12.0	12	43	11	40	3	22	
5/ 3/81	1300	10717.0	2.0	12.0	9	44	8	41	2	22	
5/ 3/81	1315	10717.0	2.1	12.1	8	45	7	42	2	23	
5/ 3/81	1330	10717.0	2.0	12.0	8	45	7	42	2	23	
5/ 3/81	1345	10717.0	2.2	12.0	7	46	6	44	2	23	
5/ 3/81	1400	10717.0	2.1	12.0	7	46	6	43	2	23	
5/ 3/81	1415	10717.0	2.3	11.8	7	47	6	45	2	24	
5/ 3/81	1430	10717.0	2.1	12.0	8	45	7	42	2	23	
5/ 3/81	1445	10717.0	2.0	12.0	6	45	5	42	1	23	
5/ 3/81	1500	10717.0	2.0	12.0	8	45	7	42	2	23	
5/ 3/81	1515	10717.0	2.3	11.9	8	48	7	46	2	25	
5/ 3/81	1530	10717.0	2.2	11.9	8	47	7	44	2	24	
5/ 3/81	1545	10717.0	1.7	12.3	8	42	7	39	2	21	
5/ 3/81	1600	10717.0	1.8	12.2	9	43	8	40	2	21	
5/ 3/81	1615	10717.0	2.0	12.0	8	45	7	42	2	23	
5/ 3/81	1630	10717.0	1.9	12.0	7	44	6	41	2	22	
5/ 3/81	1645	10717.0	1.9	12.1	7	45	6	42	2	22	
5/ 3/81	1700	10717.0	2.0	12.0	7	46	6	43	2	23	
5/ 3/81	1715	10717.0	1.8	12.2	7	44	6	41	2	22	
5/ 3/81	1730	10717.0	1.8	12.2	8	43	7	40	2	21	
5/ 3/81	1745	10717.0	2.0	12.0	7	45	6	42	2	23	
5/ 3/81	1800	10717.0	1.9	12.1	7	45	6	42	2	22	
5/ 3/81	1815	10717.0	1.9	12.1	7	44	6	41	2	22	
5/ 3/81	1830	10717.0	1.9	12.1	8	43	7	40	2	21	
5/ 3/81	1845	10717.0	1.8	12.2	8	43	7	40	2	21	
5/ 3/81	1900	10717.0	1.9	12.1	8	44	7	41	2	22	
5/ 3/81	1915	10717.0	1.9	12.1	9	43	8	40	2	21	
5/ 3/81	1930	10717.0	1.9	12.1	9	44	8	41	2	22	
5/ 3/81	1945	10717.0	2.0	12.0	8	45	7	42	2	23	
5/ 3/81	2000	10717.0	1.9	12.1	9	44	8	41	2	22	
5/ 3/81	2015	10717.0	1.9	12.1	9	44	8	41	2	22	
5/ 3/81	2030	10717.0	1.9	12.1	8	45	7	42	2	22	
5/ 3/81	2045	10717.0	2.0	12.0	7	45	6	42	2	23	
5/ 3/81	2100	10717.0	2.0	12.0	6	45	5	42	1	23	
5/ 3/81	2115	10717.0	2.1	12.1	9	46	8	43	2	23	
5/ 3/81	2130	10717.0	2.2	11.8	9	46	8	44	2	23	
5/ 3/81	2145	10717.0	2.2	11.9	9	46	8	44	2	23	
5/ 3/81	2200	10717.0	2.3	11.8	8	46	7	44	2	24	
5/ 3/81	2215	10717.0	2.3	11.9	7	47	6	45	2	24	
5/ 3/81	2230	10717.0	2.3	11.9	7	47	6	45	2	24	
5/ 3/81	2245	10717.0	2.4	11.8	6	48	5	46	1	25	
5/ 3/81	2300	10717.0	2.3	11.8	7	47	6	45	2	24	
5/ 3/81	2315	10717.0	2.3	11.8	7	47	6	45	2	24	
5/ 3/81	2330	10717.0	2.3	11.9	7	47	6	45	2	24	
5/ 3/81	2345	10717.0	2.2	11.9	8	46	7	44	2	23	
5/ 3/81	2400	10717.0	2.4	11.8	6	47	5	45	1	24	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 4/81	15	10717.0	2.4	11.8	6	47	5	45	1	24	
5/ 4/81	30	10717.0	2.3	11.9	6	46	5	44	1	24	
5/ 4/81	45	10717.0	2.3	11.9	5	47	4	45	1	24	
5/ 4/81	100	10717.0	2.4	11.8	6	47	5	45	1	24	
5/ 4/81	115	10717.0	2.3	11.9	6	47	5	45	1	24	
5/ 4/81	130	10717.0	2.4	11.8	6	47	5	45	1	24	
5/ 4/81	145	10717.0	2.3	11.9	5	47	4	45	1	24	
5/ 4/81	200	10717.0	2.3	11.9	4	46	3	44	1	24	
5/ 4/81	215	10717.0	2.3	11.9	5	46	4	44	1	24	
5/ 4/81	230	10717.0	2.3	11.9	10	47	9	45	3	24	
5/ 4/81	245	10717.0	2.4	11.8	9	47	8	45	2	24	
5/ 4/81	300	10717.0	2.4	11.8	10	46	9	44	3	24	
5/ 4/81	315	10717.0	2.4	11.8	10	47	9	45	3	24	
5/ 4/81	330	10717.0	2.4	11.8	9	47	8	45	2	24	
5/ 4/81	345	10717.0	2.4	11.8	10	47	9	45	3	24	
5/ 4/81	400	10717.0	2.3	11.9	9	46	8	44	2	24	
5/ 4/81	415	10717.0	2.4	11.8	12	47	11	45	3	24	
5/ 4/81	430	10717.0	2.4	11.8	10	47	9	45	3	24	
5/ 4/81	445	10717.0	2.2	11.9	11	45	10	43	3	23	
5/ 4/81	500	10717.0	2.3	11.9	13	46	12	44	4	24	
5/ 4/81	515	10717.0	2.3	11.9	12	46	11	44	3	24	
5/ 4/81	530	10717.0	2.4	11.8	10	46	9	44	3	24	
5/ 4/81	545	10717.0	2.4	11.8	10	46	9	44	3	24	
5/ 4/81	600	10717.0	2.4	11.8	11	46	10	44	3	24	
5/ 4/81	615	10717.0	2.3	11.9	11	46	10	44	3	24	
5/ 4/81	630	10717.0	2.3	11.9	12	45	11	43	3	23	
5/ 4/81	645	10717.0	2.3	11.9	12	45	11	43	3	23	
5/ 4/81	700	10717.0	2.3	11.9	11	46	10	44	3	24	
5/ 4/81	715	10717.0	2.2	11.9	10	45	9	43	3	23	
5/ 4/81	730	10717.0	2.3	11.9	10	46	9	44	3	24	
5/ 4/81	745	10717.0	2.3	11.9	9	46	8	44	2	24	
5/ 4/81	800	10717.0	2.4	11.8	9	47	8	45	2	24	
5/ 4/81	815	10717.0	2.6	11.7	9	49	8	47	2	26	
5/ 4/81	830	10717.0	2.2	11.9	11	45	10	43	3	23	
5/ 4/81	845	10717.0	2.4	11.8	12	47	11	45	3	24	
5/ 4/81	900	10717.0	2.3	11.9	10	47	9	45	3	24	
5/ 4/81	915	10717.0	2.3	11.9	10	47	9	45	3	24	
5/ 4/81	930	10717.0	2.1	12.0	10	45	9	42	3	23	
5/ 4/81	945	10717.0	2.4	11.8	10	48	9	46	3	25	
5/ 4/81	1000	10717.0	2.5	11.7	9	48	8	46	2	25	
5/ 4/81	1015	10717.0	2.4	11.8	10	47	9	45	3	24	
5/ 4/81	1030	10717.0	2.4	11.8	10	48	9	46	3	25	
5/ 4/81	1045	10717.0	2.3	11.9	9	47	8	45	2	24	
5/ 4/81	1100	10717.0	2.2	11.9	9	46	8	44	2	23	
5/ 4/81	1115	10717.0	2.3	11.9	9	48	8	46	2	25	
5/ 4/81	1130	10717.0	2.5	11.7	7	49	6	47	2	25	
5/ 4/81	1145	10717.0	2.3	11.9	7	49	6	47	2	25	
5/ 4/81	1200	10717.0	.0	.0	0	0	0	0	0	0	C

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 4/81	1215	10717.0	1.9	12.1	54	62	50	58	16	31	
5/ 4/81	1230	10717.0	2.3	11.9	10	44	9	42	3	22	
5/ 4/81	1245	10717.0	2.3	11.9	10	44	9	42	3	22	
5/ 4/81	1300	10717.0	2.3	11.9	9	44	8	42	2	22	
5/ 4/81	1315	10717.0	2.3	11.9	8	44	7	42	2	22	
5/ 4/81	1330	10717.0	2.2	11.9	7	43	6	41	2	22	
5/ 4/81	1345	10717.0	2.1	12.0	7	42	6	39	2	21	
5/ 4/81	1400	10717.0	2.2	11.9	7	43	6	41	2	22	
5/ 4/81	1415	10717.0	2.2	11.9	8	43	7	41	2	22	
5/ 4/81	1430	10717.0	2.2	11.9	12	43	11	41	3	22	
5/ 4/81	1445	10717.0	2.2	11.9	14	43	13	41	4	22	
5/ 4/81	1500	10717.0	2.2	11.9	14	44	13	42	4	22	
5/ 4/81	1515	10717.0	2.1	12.0	15	42	14	39	4	21	
5/ 4/81	1530	10717.0	2.2	11.9	13	42	12	40	4	21	
5/ 4/81	1545	10717.0	2.1	12.0	0	43	0	40	0	22	
5/ 4/81	1600	10717.0	2.1	12.0	7	43	6	40	2	22	
5/ 4/81	1615	10717.0	2.0	12.0	15	43	14	40	4	22	
5/ 4/81	1630	10717.0	2.2	11.9	12	39	11	37	3	20	
5/ 4/81	1645	10717.0	2.1	12.0	14	39	13	37	4	20	
5/ 4/81	1700	10717.0	2.0	12.0	13	38	12	35	4	19	
5/ 4/81	1715	10717.0	2.1	12.0	13	40	12	38	4	20	
5/ 4/81	1730	10717.0	1.9	12.1	14	38	13	35	4	19	
5/ 4/81	1745	10717.0	1.9	12.1	14	39	13	36	4	19	
5/ 4/81	1800	10717.0	2.1	12.0	14	39	13	37	4	20	
5/ 4/81	1815	10717.0	1.9	12.1	19	38	17	35	5	19	
5/ 4/81	1830	10717.0	1.9	12.1	24	38	22	35	7	19	
5/ 4/81	1845	10717.0	1.9	12.1	23	39	21	36	7	19	
5/ 4/81	1900	10717.0	1.9	12.1	23	39	21	36	7	19	
5/ 4/81	1915	10717.0	1.9	12.1	24	39	22	36	7	19	
5/ 4/81	1930	10717.0	2.0	12.0	24	40	22	37	7	20	
5/ 4/81	1945	10717.0	2.0	12.0	25	39	23	36	7	20	
5/ 4/81	2000	10717.0	2.1	12.0	24	40	22	38	7	20	
5/ 4/81	2015	10717.0	2.1	12.0	24	40	22	38	7	20	
5/ 4/81	2030	10717.0	2.1	12.0	24	40	22	38	7	20	
5/ 4/81	2045	10717.0	2.1	12.0	24	41	22	39	7	21	
5/ 4/81	2100	10717.0	2.2	11.9	24	42	22	40	7	21	
5/ 4/81	2115	10717.0	2.2	11.9	24	41	22	39	7	21	
5/ 4/81	2130	10717.0	2.3	11.9	25	42	24	40	7	21	
5/ 4/81	2145	10717.0	2.4	11.8	25	43	24	41	7	22	
5/ 4/81	2200	10717.0	2.3	11.9	25	42	24	40	7	21	
5/ 4/81	2215	10717.0	2.2	11.9	24	42	22	40	7	21	
5/ 4/81	2230	10717.0	2.3	11.9	24	43	23	41	7	22	
5/ 4/81	2245	10717.0	2.3	11.9	25	42	24	40	7	21	
5/ 4/81	2300	10717.0	2.3	11.9	25	42	24	40	7	21	
5/ 4/81	2315	10717.0	2.2	11.9	24	42	22	40	7	21	
5/ 4/81	2330	10717.0	2.1	12.0	24	41	22	39	7	21	
5/ 4/81	2345	10717.0	2.2	11.9	25	41	23	39	7	21	
5/ 4/81	2400	10717.0	2.3	11.9	24	41	23	39	7	21	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 5/81	15	10717.0	2.2	11.9	25	40	23	38	7	20	
5/ 5/81	30	10717.0	2.1	12.0	25	39	23	37	7	20	
5/ 5/81	45	10717.0	2.3	11.9	25	42	24	40	7	21	
5/ 5/81	100	10717.0	2.2	11.9	26	41	24	39	8	21	
5/ 5/81	115	10717.0	2.3	11.9	25	41	24	39	7	21	
5/ 5/81	130	10717.0	2.3	11.9	25	41	24	39	7	21	
5/ 5/81	145	10717.0	2.3	11.9	25	41	24	39	7	21	
5/ 5/81	200	10717.0	2.3	11.9	24	41	23	39	7	21	
5/ 5/81	215	10717.0	2.1	12.0	24	39	22	37	7	20	
5/ 5/81	230	10717.0	.9	12.8	873	26	781	23	257	12	
5/ 5/81	245	10717.0	2.2	11.9	45	39	43	37	14	20	
5/ 5/81	300	10717.0	2.3	11.9	29	41	27	39	9	21	
5/ 5/81	315	10717.0	2.5	11.7	26	43	25	41	8	22	
5/ 5/81	330	10717.0	2.4	11.8	26	42	25	40	8	22	
5/ 5/81	345	10717.0	2.3	11.9	24	41	23	39	7	21	
5/ 5/81	400	10717.0	2.5	11.7	24	43	23	41	7	22	
5/ 5/81	415	10717.0	2.5	11.7	24	43	23	41	7	22	
5/ 5/81	430	10717.0	2.7	11.6	23	45	22	44	7	24	
5/ 5/81	445	10717.0	2.5	11.7	24	43	23	41	7	22	
5/ 5/81	500	10717.0	2.4	11.8	24	41	23	39	7	21	
5/ 5/81	515	10717.0	2.4	11.8	24	42	23	40	7	22	
5/ 5/81	530	10717.0	2.5	11.7	25	44	24	42	8	23	
5/ 5/81	545	10717.0	2.6	11.7	25	44	24	43	8	23	
5/ 5/81	600	10717.0	2.5	11.7	25	43	24	41	8	22	
5/ 5/81	615	10717.0	2.5	11.7	26	43	25	41	8	22	
5/ 5/81	630	10717.0	2.6	11.7	26	43	25	42	8	22	
5/ 5/81	645	10717.0	2.6	11.7	25	43	24	42	8	22	
5/ 5/81	700	10717.0	2.6	11.7	25	44	24	43	8	23	
5/ 5/81	715	10717.0	2.6	11.7	26	44	25	43	8	23	
5/ 5/81	730	10717.0	2.5	11.7	26	44	25	42	8	23	
5/ 5/81	745	10717.0	2.7	11.6	25	45	24	44	8	24	
5/ 5/81	800	10717.0	2.8	11.5	26	46	25	45	8	24	
5/ 5/81	815	10717.0	2.9	11.5	26	47	25	46	8	25	
5/ 5/81	830	10717.0	2.9	11.5	26	47	25	46	8	25	
5/ 5/81	845	10717.0	2.7	11.6	25	46	24	45	8	24	
5/ 5/81	900	10717.0	2.7	11.6	25	47	24	46	8	25	
5/ 5/81	915	10717.0	2.4	11.8	25	44	24	42	7	23	
5/ 5/81	930	10717.0	2.6	11.7	24	46	23	44	7	24	
5/ 5/81	945	10717.0	2.5	11.7	25	46	24	44	8	24	
5/ 5/81	1000	10717.0	2.5	11.7	25	46	24	44	8	24	
5/ 5/81	1015	10717.0	2.4	11.8	26	45	25	43	8	23	
5/ 5/81	1030	10717.0	2.4	11.8	26	46	25	44	8	24	
5/ 5/81	1045	10717.0	2.7	11.6	25	48	24	47	8	25	
5/ 5/81	1100	10717.0	2.7	11.6	25	48	24	47	8	25	
5/ 5/81	1115	10717.0	2.2	11.9	25	49	23	46	7	25	
5/ 5/81	1130	10717.0	2.5	11.7	25	47	24	45	8	24	
5/ 5/81	1145	10717.0	2.6	11.7	21	47	20	45	6	24	
5/ 5/81	1200	10717.0	.0	.0	0	0	0	0	0	0	C

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 5/81	1215	10717.0	2.8	11.5	20	49	19	48	6	26	
5/ 5/81	1230	10717.0	2.6	11.7	69	50	67	48	22	26	
5/ 5/81	1245	10717.0	2.4	11.8	11	46	10	44	3	24	
5/ 5/81	1300	10717.0	2.5	11.7	8	47	7	45	2	24	
5/ 5/81	1315	10717.0	2.4	11.8	6	46	5	44	1	24	
5/ 5/81	1330	10717.0	2.6	11.7	5	47	4	45	1	24	
5/ 5/81	1345	10717.0	2.4	11.8	5	46	4	44	1	24	
5/ 5/81	1400	10717.0	2.5	11.7	8	46	7	44	2	24	
5/ 5/81	1415	10717.0	2.3	11.9	11	44	10	42	3	22	
5/ 5/81	1430	10717.0	2.4	11.8	9	46	8	44	2	24	
5/ 5/81	1445	10717.0	1.9	12.1	141	41	132	38	43	20	
5/ 5/81	1500	10717.0	2.1	12.0	3	43	2	40	0	22	
5/ 5/81	1515	10717.0	2.2	11.9	6	43	5	41	1	22	
5/ 5/81	1530	10717.0	2.1	12.0	7	42	6	39	2	21	
5/ 5/81	1545	10717.0	2.0	12.0	5	42	4	39	1	21	
5/ 5/81	1600	10717.0	2.1	12.0	5	42	4	39	1	21	
5/ 5/81	1615	10717.0	2.1	12.0	5	42	4	39	1	21	
5/ 5/81	1630	10717.0	2.2	11.9	4	44	3	42	1	22	
5/ 5/81	1645	10717.0	2.0	12.0	8	42	7	39	2	21	
5/ 5/81	1700	10717.0	1.9	12.1	12	41	11	38	3	20	
5/ 5/81	1715	10717.0	1.6	12.3	14	38	12	35	4	19	
5/ 5/81	1730	10717.0	2.0	12.0	15	40	14	37	4	20	
5/ 5/81	1745	10717.0	1.9	12.1	12	41	11	38	3	20	
5/ 5/81	1800	10717.0	1.9	12.1	12	40	11	37	3	20	
5/ 5/81	1815	10717.0	1.7	12.3	11	39	10	36	3	19	
5/ 5/81	1830	10717.0	1.7	12.3	13	39	12	36	3	19	
5/ 5/81	1845	10717.0	1.8	12.2	14	39	13	36	4	19	
5/ 5/81	1900	10717.0	2.0	12.0	12	41	11	38	3	21	
5/ 5/81	1915	10717.0	1.5	12.4	13	37	11	34	3	18	
5/ 5/81	1930	10717.0	1.8	12.2	12	40	11	37	3	20	
5/ 5/81	1945	10717.0	2.0	12.0	11	41	10	38	3	21	
5/ 5/81	2000	10717.0	1.9	12.1	11	41	10	38	3	20	
5/ 5/81	2015	10717.0	1.7	12.3	12	39	11	36	3	19	
5/ 5/81	2030	10717.0	1.9	12.1	12	41	11	38	3	20	
5/ 5/81	2045	10717.0	1.8	12.2	9	41	8	38	2	20	
5/ 5/81	2100	10717.0	2.0	12.0	11	42	10	39	3	21	
5/ 5/81	2115	10717.0	2.0	12.0	12	42	11	39	3	21	
5/ 5/81	2130	10717.0	2.0	12.0	12	42	11	39	3	21	
5/ 5/81	2145	10717.0	2.1	12.0	12	43	11	40	3	22	
5/ 5/81	2200	10717.0	1.9	12.1	12	42	11	39	3	21	
5/ 5/81	2215	10717.0	2.0	12.0	12	42	11	39	3	21	
5/ 5/81	2230	10717.0	2.0	12.0	12	42	11	39	3	21	
5/ 5/81	2245	10717.0	2.1	12.0	9	42	8	39	2	21	
5/ 5/81	2300	10717.0	2.2	11.9	10	44	9	42	3	22	
5/ 5/81	2315	10717.0	2.2	11.9	8	44	7	42	2	22	
5/ 5/81	2330	10717.0	2.2	11.9	7	44	6	42	2	22	
5/ 5/81	2345	10717.0	2.1	12.0	7	44	6	41	2	22	
5/ 5/81	2400	10717.0	2.0	12.0	7	42	6	39	2	21	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 6/81	15	10717.0	2.1	12.0	9	43	8	40	2	22	
5/ 6/81	30	10717.0	2.0	12.0	37	41	35	38	11	21	
5/ 6/81	45	10717.0	1.6	12.3	4	39	3	36	1	19	
5/ 6/81	100	10717.0	2.0	12.0	11	42	10	39	3	21	
5/ 6/81	115	10717.0	2.3	11.9	10	45	9	43	3	23	
5/ 6/81	130	10717.0	2.3	11.9	9	44	8	42	2	22	
5/ 6/81	145	10717.0	2.2	11.9	11	43	10	41	3	22	
5/ 6/81	200	10717.0	2.1	12.0	12	43	11	40	3	22	
5/ 6/81	215	10717.0	2.1	12.0	12	43	11	40	3	22	
5/ 6/81	230	10717.0	2.2	11.9	10	43	9	41	3	22	
5/ 6/81	245	10717.0	2.3	11.9	11	45	10	43	3	23	
5/ 6/81	300	10717.0	2.3	11.9	11	46	10	44	3	24	
5/ 6/81	315	10717.0	2.5	11.7	13	46	12	44	4	24	
5/ 6/81	330	10717.0	2.4	11.8	13	45	12	43	4	23	
5/ 6/81	345	10717.0	2.2	11.9	14	44	13	42	4	22	
5/ 6/81	400	10717.0	2.1	12.0	13	43	12	40	4	22	
5/ 6/81	415	10717.0	2.3	11.9	14	44	13	42	4	22	
5/ 6/81	430	10717.0	2.3	11.9	14	44	13	42	4	22	
5/ 6/81	445	10717.0	2.2	11.9	14	44	13	42	4	22	
5/ 6/81	500	10717.0	2.5	11.7	13	46	12	44	4	24	
5/ 6/81	515	10717.0	2.6	11.7	13	48	12	46	4	25	
5/ 6/81	530	10717.0	2.7	11.6	12	48	11	47	3	25	
5/ 6/81	545	10717.0	2.7	11.6	11	49	10	48	3	26	
5/ 6/81	600	10717.0	2.7	11.6	11	48	10	47	3	25	
5/ 6/81	615	10717.0	2.9	11.5	9	49	8	48	2	26	
5/ 6/81	630	10717.0	2.9	11.5	9	49	8	48	2	26	
5/ 6/81	645	10717.0	2.9	11.5	11	49	10	48	3	26	
5/ 6/81	700	10717.0	2.9	11.5	11	49	10	48	3	26	
5/ 6/81	715	10717.0	2.9	11.5	8	49	7	48	2	26	
5/ 6/81	730	10717.0	2.9	11.5	9	49	8	48	2	26	
5/ 6/81	745	10717.0	2.8	11.5	10	49	9	48	3	26	
5/ 6/81	800	10717.0	2.6	11.7	12	48	11	46	3	25	
5/ 6/81	815	10717.0	2.6	11.7	12	48	11	46	3	25	
5/ 6/81	830	10717.0	2.7	11.6	11	49	10	48	3	26	
5/ 6/81	845	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 6/81	900	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 6/81	915	10717.0	2.6	11.7	13	48	12	46	4	25	
5/ 6/81	930	10717.0	2.7	11.6	11	49	10	48	3	26	
5/ 6/81	945	10717.0	2.6	11.7	12	47	11	45	3	24	
5/ 6/81	1000	10717.0	2.6	11.7	11	46	10	44	3	24	
5/ 6/81	1015	10717.0	2.6	11.7	11	46	10	44	3	24	
5/ 6/81	1030	10717.0	2.6	11.7	12	47	11	45	3	24	
5/ 6/81	1045	10717.0	2.6	11.7	13	47	12	45	4	24	
5/ 6/81	1100	10717.0	2.5	11.7	13	47	12	45	4	24	
5/ 6/81	1115	10717.0	2.5	11.7	12	47	11	45	3	24	
5/ 6/81	1130	10717.0	2.6	11.7	11	48	10	46	3	25	
5/ 6/81	1145	10717.0	2.6	11.7	11	47	10	45	3	24	
5/ 6/81	1200	10717.0	2.6	11.7	11	48	10	46	3	25	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL

15 MIN. DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 6/81	1215	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 6/81	1230	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 6/81	1245	10717.0	.0	.0	0	0	0	0	0	0	I
5/ 6/81	1300	10717.0	.0	.0	0	0	0	0	0	0	I
5/ 6/81	1315	10717.0	2.6	11.7	43	38	42	37	13	20	
5/ 6/81	1330	10717.0	2.9	11.5	7	47	6	46	2	25	
5/ 6/81	1345	10717.0	2.7	11.6	7	46	6	45	2	24	
5/ 6/81	1400	10717.0	2.7	11.6	7	45	6	44	2	24	
5/ 6/81	1415	10717.0	3.0	11.4	0	45	0	45	0	24	
5/ 6/81	1430	10717.0	2.9	11.5	5	47	4	46	1	25	
5/ 6/81	1445	10717.0	2.8	11.5	5	49	4	48	1	26	
5/ 6/81	1500	10717.0	2.8	11.5	7	47	6	46	2	25	
5/ 6/81	1515	10717.0	2.7	11.6	6	46	5	45	1	24	
5/ 6/81	1530	10717.0	2.8	11.5	7	47	6	46	2	25	
5/ 6/81	1545	10717.0	2.8	11.5	7	47	6	46	2	25	
5/ 6/81	1600	10717.0	2.6	11.7	5	44	4	43	1	23	
5/ 6/81	1615	10717.0	2.5	11.7	4	43	3	41	1	22	
5/ 6/81	1630	10717.0	2.6	11.7	4	44	3	43	1	23	
5/ 6/81	1645	10717.0	.0	.0	0	0	0	0	0	0	I
5/ 6/81	1700	10717.0	2.6	11.7	2	43	1	42	0	22	
5/ 6/81	1715	10717.0	2.5	11.7	2	43	1	41	0	22	
5/ 6/81	1730	10717.0	2.5	11.7	2	43	1	41	0	22	
5/ 6/81	1745	10717.0	2.4	11.8	0	42	0	40	0	22	
5/ 6/81	1800	10717.0	2.3	11.9	0	41	0	39	0	21	
5/ 6/81	1815	10717.0	2.3	11.9	0	41	0	39	0	21	
5/ 6/81	1830	10717.0	2.4	11.8	0	42	0	40	0	22	
5/ 6/81	1845	10717.0	2.2	11.9	0	40	0	38	0	20	
5/ 6/81	1900	10717.0	2.4	11.8	1	41	0	39	0	21	
5/ 6/81	1915	10717.0	2.3	11.9	2	41	1	39	0	21	
5/ 6/81	1930	10717.0	2.4	11.8	2	42	1	40	0	22	
5/ 6/81	1945	10717.0	2.4	11.8	3	42	2	40	0	22	
5/ 6/81	2000	10717.0	2.4	11.8	4	43	3	41	1	22	
5/ 6/81	2015	10717.0	2.4	11.8	1	42	0	40	0	22	
5/ 6/81	2030	10717.0	2.4	11.8	1	42	0	40	0	22	
5/ 6/81	2045	10717.0	2.4	11.8	1	42	0	40	0	22	
5/ 6/81	2100	10717.0	2.4	11.8	2	42	1	40	0	22	
5/ 6/81	2115	10717.0	2.4	11.8	1	43	0	41	0	22	
5/ 6/81	2130	10717.0	2.6	11.7	0	44	0	43	0	23	
5/ 6/81	2145	10717.0	2.6	11.7	0	44	0	43	0	23	
5/ 6/81	2200	10717.0	2.6	11.7	0	43	0	42	0	22	
5/ 6/81	2215	10717.0	2.6	11.7	1	42	0	41	0	22	
5/ 6/81	2230	10717.0	2.6	11.7	3	42	2	41	0	22	
5/ 6/81	2245	10717.0	2.3	11.9	5	40	4	38	1	20	
5/ 6/81	2300	10717.0	2.6	11.7	7	43	6	42	2	22	
5/ 6/81	2315	10717.0	2.7	11.6	4	43	3	42	1	22	
5/ 6/81	2330	10717.0	2.8	11.5	6	44	5	43	1	23	
5/ 6/81	2345	10717.0	2.8	11.5	5	44	4	43	1	23	
5/ 6/81	2400	10717.0	2.7	11.6	4	44	3	43	1	23	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 7/81	15	10717.0	2.7	11.6	4	44	3	43	1	23	
5/ 7/81	30	10717.0	2.7	11.6	5	45	4	44	1	24	
5/ 7/81	45	10717.0	2.9	11.5	7	46	6	45	2	24	
5/ 7/81	100	10717.0	3.0	11.4	6	46	6	46	1	24	
5/ 7/81	115	10717.0	2.8	11.5	4	45	3	44	1	24	
5/ 7/81	130	10717.0	2.9	11.5	2	46	1	45	0	24	
5/ 7/81	145	10717.0	2.8	11.5	0	45	0	44	0	24	
5/ 7/81	200	10717.0	2.9	11.5	1	46	0	45	0	24	
5/ 7/81	215	10717.0	2.9	11.5	2	45	1	44	0	24	
5/ 7/81	230	10717.0	2.9	11.5	0	45	0	44	0	24	
5/ 7/81	245	10717.0	2.9	11.5	0	44	0	43	0	23	
5/ 7/81	300	10717.0	2.9	11.5	4	43	3	42	1	23	
5/ 7/81	315	10717.0	2.8	11.5	5	43	4	42	1	23	
5/ 7/81	330	10717.0	2.8	11.5	6	43	5	42	1	23	
5/ 7/81	345	10717.0	2.8	11.5	7	43	6	42	2	23	
5/ 7/81	400	10717.0	2.7	11.6	6	42	5	41	1	22	
5/ 7/81	415	10717.0	2.7	11.6	5	42	4	41	1	22	
5/ 7/81	430	10717.0	2.8	11.5	6	43	5	42	1	23	
5/ 7/81	445	10717.0	2.7	11.6	7	43	6	42	2	22	
5/ 7/81	500	10717.0	2.8	11.5	7	43	6	42	2	23	
5/ 7/81	515	10717.0	2.8	11.5	7	43	6	42	2	23	
5/ 7/81	530	10717.0	2.8	11.5	7	44	6	43	2	23	
5/ 7/81	545	10717.0	2.9	11.5	7	45	6	44	2	24	
5/ 7/81	600	10717.0	3.0	11.4	6	45	6	45	1	24	
5/ 7/81	615	10717.0	2.9	11.5	6	44	5	43	1	23	
5/ 7/81	630	10717.0	2.8	11.5	7	44	6	43	2	23	
5/ 7/81	645	10717.0	.0	.0	0	0	0	0	0	0	K
5/ 7/81	700	10717.0	2.2	11.9	942	30	901	28	296	15	
5/ 7/81	715	10717.0	5.0	10.1	29	44	32	49	10	26	
5/ 7/81	730	10717.0	3.5	11.1	11	39	11	40	3	21	
5/ 7/81	745	10717.0	3.0	11.4	301	35	301	35	99	18	
5/ 7/81	800	10717.0	3.8	10.9	6	55	6	57	2	31	
5/ 7/81	815	10717.0	4.0	10.8	8	57	8	60	2	32	
5/ 7/81	830	10717.0	3.9	10.9	8	57	8	60	2	32	
5/ 7/81	845	10717.0	3.9	10.9	0	58	0	61	0	33	
5/ 7/81	900	10717.0	3.9	10.9	7	58	7	61	2	33	
5/ 7/81	915	10717.0	3.9	10.9	4	59	4	62	1	33	
5/ 7/81	930	10717.0	3.6	11.0	5	58	5	60	1	32	
5/ 7/81	945	10717.0	3.9	10.9	6	59	6	62	2	33	
5/ 7/81	1000	10717.0	3.6	11.1	5	57	5	58	1	31	
5/ 7/81	1015	10717.0	3.6	11.0	5	57	5	58	1	31	
5/ 7/81	1030	10717.0	3.8	10.9	5	59	5	61	1	33	
5/ 7/81	1045	10717.0	3.8	10.9	5	59	5	61	1	33	
5/ 7/81	1100	10717.0	2.8	11.5	403	44	398	43	131	23	
5/ 7/81	1115	10717.0	1.3	12.5	0	32	0	29	0	15	
5/ 7/81	1130	10717.0	1.9	12.1	3	37	2	34	0	18	
5/ 7/81	1145	10717.0	2.0	12.0	10	37	9	35	3	19	
5/ 7/81	1200	10717.0	2.1	12.0	7	39	6	37	2	20	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 7/81	1215	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 7/81	1230	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 7/81	1245	10717.0	2.7	11.6	4	46	3	45	1	24	
5/ 7/81	1300	10717.0	4.9	10.2	2	70	2	78	0	42	
5/ 7/81	1315	10717.0	2.8	11.5	0	47	0	46	0	25	
5/ 7/81	1330	10717.0	1.5	12.4	10	33	9	30	3	16	
5/ 7/81	1345	10717.0	2.0	12.0	5	39	4	36	1	20	
5/ 7/81	1400	10717.0	2.3	11.9	4	42	3	40	1	21	
5/ 7/81	1415	10717.0	2.5	11.7	4	44	3	42	1	23	
5/ 7/81	1430	10717.0	2.4	11.8	5	43	4	41	1	22	
5/ 7/81	1445	10717.0	2.4	11.8	5	43	4	41	1	22	
5/ 7/81	1500	10717.0	2.4	11.8	2	43	1	41	0	22	
5/ 7/81	1515	10717.0	2.4	11.8	0	42	0	40	0	22	
5/ 7/81	1530	10717.0	2.4	11.8	0	42	0	40	0	22	
5/ 7/81	1545	10717.0	2.2	11.9	2	41	1	39	0	21	
5/ 7/81	1600	10717.0	2.2	11.9	2	42	1	40	0	21	
5/ 7/81	1615	10717.0	2.4	11.8	3	43	2	41	0	22	
5/ 7/81	1630	10717.0	2.2	11.9	1	42	0	40	0	21	
5/ 7/81	1645	10717.0	2.3	11.9	3	43	2	41	0	22	
5/ 7/81	1700	10717.0	2.1	12.0	3	41	2	39	0	21	
5/ 7/81	1715	10717.0	2.1	12.0	4	41	3	39	1	21	
5/ 7/81	1730	10717.0	2.0	12.0	4	40	3	37	1	20	
5/ 7/81	1745	10717.0	2.0	12.0	3	39	2	36	0	20	
5/ 7/81	1800	10717.0	2.0	12.0	3	39	2	36	0	20	
5/ 7/81	1815	10717.0	2.0	12.0	2	39	1	36	0	20	
5/ 7/81	1830	10717.0	2.1	12.0	2	40	1	38	0	20	
5/ 7/81	1845	10717.0	1.8	12.2	3	38	2	35	0	19	
5/ 7/81	1900	10717.0	2.0	12.0	4	39	3	36	1	20	
5/ 7/81	1915	10717.0	2.1	12.0	4	40	3	38	1	20	
5/ 7/81	1930	10717.0	2.1	12.0	3	40	2	38	0	20	
5/ 7/81	1945	10717.0	2.2	11.9	3	41	2	39	0	21	
5/ 7/81	2000	10717.0	2.3	11.9	2	42	1	40	0	21	
5/ 7/81	2015	10717.0	2.3	11.9	2	42	1	40	0	21	
5/ 7/81	2030	10717.0	2.2	11.9	1	42	0	40	0	21	
5/ 7/81	2045	10717.0	2.2	11.9	2	41	1	39	0	21	
5/ 7/81	2100	10717.0	2.3	11.9	2	42	1	40	0	21	
5/ 7/81	2115	10717.0	2.3	11.9	2	42	1	40	0	21	
5/ 7/81	2130	10717.0	2.3	11.9	3	41	2	39	0	21	
5/ 7/81	2145	10717.0	2.4	11.8	2	41	1	39	0	21	
5/ 7/81	2200	10717.0	2.3	11.9	1	40	0	38	0	20	
5/ 7/81	2215	10717.0	2.2	11.9	8	40	7	38	2	20	
5/ 7/81	2230	10717.0	2.4	11.8	7	41	6	39	2	21	
5/ 7/81	2245	10717.0	2.5	11.7	4	42	3	40	1	22	
5/ 7/81	2300	10717.0	2.4	11.8	3	42	2	40	0	22	
5/ 7/81	2315	10717.0	2.4	11.8	4	43	3	41	1	22	
5/ 7/81	2330	10717.0	2.5	11.7	3	44	2	42	0	23	
5/ 7/81	2345	10717.0	2.5	11.7	2	44	1	42	0	23	
5/ 7/81	2400	10717.0	2.6	11.7	1	44	0	43	0	23	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 8/81	15	10717.0	2.6	11.7	3	44	2	43	0	23	
5/ 8/81	30	10717.0	2.8	11.5	3	45	2	44	0	24	
5/ 8/81	45	10717.0	2.6	11.7	4	43	3	42	1	22	
5/ 8/81	100	10717.0	2.6	11.7	6	43	5	42	1	22	
5/ 8/81	115	10717.0	2.6	11.7	5	43	4	42	1	22	
5/ 8/81	130	10717.0	2.6	11.7	4	42	3	41	1	22	
5/ 8/81	145	10717.0	2.8	11.5	7	44	6	43	2	23	
5/ 8/81	200	10717.0	2.9	11.5	7	44	6	43	2	23	
5/ 8/81	215	10717.0	2.8	11.5	4	44	3	43	1	23	
5/ 8/81	230	10717.0	2.7	11.6	5	43	4	42	1	22	
5/ 8/81	245	10717.0	2.8	11.5	6	44	5	43	1	23	
5/ 8/81	300	10717.0	2.8	11.5	5	44	4	43	1	23	
5/ 8/81	315	10717.0	2.7	11.6	7	44	6	43	2	23	
5/ 8/81	330	10717.0	2.7	11.6	6	43	5	42	1	22	
5/ 8/81	345	10717.0	2.9	11.5	4	44	3	43	1	23	
5/ 8/81	400	10717.0	2.8	11.5	5	43	4	42	1	23	
5/ 8/81	415	10717.0	2.7	11.6	4	42	3	41	1	22	
5/ 8/81	430	10717.0	2.7	11.6	4	43	3	42	1	22	
5/ 8/81	445	10717.0	2.8	11.5	10	43	9	42	3	23	
5/ 8/81	500	10717.0	2.8	11.5	10	44	9	43	3	23	
5/ 8/81	515	10717.0	2.7	11.6	8	42	7	41	2	22	
5/ 8/81	530	10717.0	2.6	11.7	7	42	6	41	2	22	
5/ 8/81	545	10717.0	2.6	11.7	10	42	9	41	3	22	
5/ 8/81	600	10717.0	2.8	11.5	10	43	9	42	3	23	
5/ 8/81	615	10717.0	2.7	11.6	11	42	10	41	3	22	
5/ 8/81	630	10717.0	2.8	11.5	10	42	9	41	3	22	
5/ 8/81	645	10717.0	2.8	11.5	11	42	10	41	3	22	
5/ 8/81	700	10717.0	2.7	11.6	9	42	8	41	2	22	
5/ 8/81	715	10717.0	2.7	11.6	5	42	4	41	1	22	
5/ 8/81	730	10717.0	2.6	11.7	0	42	0	41	0	22	
5/ 8/81	745	10717.0	2.6	11.7	1	42	0	41	0	22	
5/ 8/81	800	10717.0	2.5	11.7	1	42	0	40	0	22	
5/ 8/81	815	10717.0	2.6	11.7	1	42	0	41	0	22	
5/ 8/81	830	10717.0	2.6	11.7	1	43	0	42	0	22	
5/ 8/81	845	10717.0	2.6	11.7	4	43	3	42	1	22	
5/ 8/81	900	10717.0	2.6	11.7	4	43	3	42	1	22	
5/ 8/81	915	10717.0	2.6	11.7	6	44	5	43	1	23	
5/ 8/81	930	10717.0	2.6	11.7	6	44	5	43	1	23	
5/ 8/81	945	10717.0	2.3	11.9	5	42	4	40	1	21	
5/ 8/81	1000	10717.0	2.4	11.8	3	42	2	40	0	22	
5/ 8/81	1015	10717.0	2.4	11.8	10	55	9	53	3	28	
5/ 8/81	1030	10717.0	2.5	11.7	10	43	9	41	3	22	
5/ 8/81	1045	10717.0	2.4	11.8	9	42	8	40	2	22	
5/ 8/81	1100	10717.0	2.3	11.9	10	42	9	40	3	21	
5/ 8/81	1115	10717.0	2.7	11.6	61	44	59	43	19	23	
5/ 8/81	1130	10717.0	2.4	11.8	15	43	14	41	4	22	
5/ 8/81	1145	10717.0	1.7	12.3	17	34	15	31	5	17	
5/ 8/81	1200	10717.0	.9	12.8	19	26	17	23	5	12	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 8/81	1215	10717.0	1.0	12.7	0	27	0	24	0	13	
5/ 8/81	1230	10717.0	1.5	12.4	15	32	13	29	4	16	
5/ 8/81	1245	10717.0	1.7	12.3	14	34	13	31	4	17	
5/ 8/81	1300	10717.0	1.9	12.1	16	36	15	33	4	18	
5/ 8/81	1315	10717.0	1.7	12.3	5	35	4	32	1	17	
5/ 8/81	1330	10717.0	1.8	12.2	11	36	10	33	3	18	
5/ 8/81	1345	10717.0	1.8	12.2	11	36	10	33	3	18	
5/ 8/81	1400	10717.0	1.8	12.2	10	37	9	34	3	18	
5/ 8/81	1415	10717.0	1.9	12.2	10	37	9	34	3	18	
5/ 8/81	1430	10717.0	1.6	12.3	5	35	4	32	1	17	
5/ 8/81	1445	10717.0	2.1	11.9	4	39	3	37	1	20	
5/ 8/81	1500	10717.0	2.1	11.5	7	40	6	38	2	20	
5/ 8/81	1515	10717.0	2.2	12.0	9	40	8	38	2	20	
5/ 8/81	1530	10717.0	2.0	11.9	4	38	3	35	1	19	
5/ 8/81	1545	10717.0	2.0	11.9	3	38	2	35	0	19	
5/ 8/81	1600	10717.0	2.0	12.1	2	39	1	36	0	20	
5/ 8/81	1615	10717.0	1.9	12.3	5	37	4	34	1	18	
5/ 8/81	1630	10717.0	2.0	11.6	3	38	2	35	0	19	
5/ 8/81	1645	10717.0	2.0	12.3	2	37	1	35	0	19	
5/ 8/81	1700	10717.0	2.0	12.6	2	38	1	35	0	19	
5/ 8/81	1715	10717.0	1.9	12.8	4	37	3	34	1	18	
5/ 8/81	1730	10717.0	1.9	12.9	4	37	3	34	1	18	
5/ 8/81	1745	10717.0	1.9	12.8	3	38	2	35	0	19	
5/ 8/81	1800	10717.0	1.7	13.0	3	35	2	32	0	17	
5/ 8/81	1815	10717.0	1.8	12.9	4	36	3	33	1	18	
5/ 8/81	1830	10717.0	1.6	13.0	3	35	2	32	0	17	
5/ 8/81	1845	10717.0	1.8	12.9	3	36	2	33	0	18	
5/ 8/81	1900	10717.0	1.7	12.7	3	35	2	32	0	17	
5/ 8/81	1915	10717.0	1.7	12.2	3	34	2	31	0	17	
5/ 8/81	1930	10717.0	1.7	11.3	2	34	1	31	0	17	
5/ 8/81	1945	10717.0	1.8	12.2	4	35	3	32	1	17	
5/ 8/81	2000	10717.0	1.8	12.2	4	36	3	33	1	18	
5/ 8/81	2015	10717.0	1.8	10.9	4	36	3	33	1	18	
5/ 8/81	2030	10717.0	1.9	12.2	5	35	4	32	1	17	
5/ 8/81	2045	10717.0	1.9	12.1	4	36	3	33	1	18	
5/ 8/81	2100	10717.0	1.9	12.1	3	37	2	34	0	18	
5/ 8/81	2115	10717.0	2.0	12.4	5	39	4	36	1	20	
5/ 8/81	2130	10717.0	1.9	12.1	6	36	5	33	1	18	
5/ 8/81	2145	10717.0	1.9	12.1	4	36	3	33	1	18	
5/ 8/81	2200	10717.0	2.0	12.3	5	37	4	35	1	19	
5/ 8/81	2215	10717.0	2.3	11.7	4	40	3	38	1	20	
5/ 8/81	2230	10717.0	2.1	12.0	5	37	4	35	1	19	
5/ 8/81	2245	10717.0	2.3	12.0	10	39	9	37	3	20	
5/ 8/81	2300	10717.0	2.1	12.4	10	37	9	35	3	19	
5/ 8/81	2315	10717.0	2.3	11.8	8	39	7	37	2	20	
5/ 8/81	2330	10717.0	2.4	11.8	8	39	7	37	2	20	
5/ 8/81	2345	10717.0	2.3	11.9	8	39	7	37	2	20	
5/ 8/81	2400	10717.0	2.2	11.9	8	38	7	36	2	19	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 9/81	15	10717.0	2.1	12.0	6	37	5	35	1	19	
5/ 9/81	30	10717.0	2.3	12.0	5	38	4	36	1	19	
5/ 9/81	45	10717.0	2.3	11.9	6	38	5	36	1	19	
5/ 9/81	100	10717.0	2.3	11.9	6	39	5	37	1	20	
5/ 9/81	115	10717.0	2.2	11.9	7	37	6	35	2	19	
5/ 9/81	130	10717.0	2.2	11.9	8	38	7	36	2	19	
5/ 9/81	145	10717.0	1.8	12.2	8	35	7	32	2	17	
5/ 9/81	200	10717.0	2.3	11.9	10	38	9	36	3	19	
5/ 9/81	215	10717.0	2.2	11.9	16	37	15	35	5	19	
5/ 9/81	230	10717.0	2.1	12.0	10	36	9	34	3	18	
5/ 9/81	245	10717.0	2.3	11.9	6	37	5	35	1	19	
5/ 9/81	300	10717.0	2.2	11.9	6	37	5	35	1	19	
5/ 9/81	315	10717.0	2.2	11.9	8	37	7	35	2	19	
5/ 9/81	330	10717.0	2.3	11.9	7	38	6	36	2	19	
5/ 9/81	345	10717.0	2.4	11.8	2	39	1	37	0	20	
5/ 9/81	400	10717.0	2.3	11.9	2	38	1	36	0	19	
5/ 9/81	415	10717.0	2.3	11.9	3	37	2	35	0	19	
5/ 9/81	430	10717.0	2.3	11.9	4	38	3	36	1	19	
5/ 9/81	445	10717.0	2.3	11.9	4	37	3	35	1	19	
5/ 9/81	500	10717.0	2.3	11.9	4	38	3	36	1	19	
5/ 9/81	515	10717.0	2.3	11.9	4	37	3	35	1	19	
5/ 9/81	530	10717.0	2.2	11.9	8	36	7	34	2	18	
5/ 9/81	545	10717.0	2.3	11.9	10	37	9	35	3	19	
5/ 9/81	600	10717.0	2.3	11.9	10	38	9	36	3	19	
5/ 9/81	615	10717.0	2.3	11.9	11	37	10	35	3	19	
5/ 9/81	630	10717.0	2.4	11.8	11	38	10	36	3	19	
5/ 9/81	645	10717.0	2.4	11.8	11	39	10	37	3	20	
5/ 9/81	700	10717.0	2.4	11.8	11	38	10	36	3	19	
5/ 9/81	715	10717.0	2.4	11.8	11	39	10	37	3	20	
5/ 9/81	730	10717.0	2.3	11.9	11	38	10	36	3	19	
5/ 9/81	745	10717.0	2.4	11.8	11	39	10	37	3	20	
5/ 9/81	800	10717.0	2.4	11.8	11	39	10	37	3	20	
5/ 9/81	815	10717.0	2.4	11.8	11	40	10	38	3	20	
5/ 9/81	830	10717.0	2.4	11.8	11	40	10	38	3	20	
5/ 9/81	845	10717.0	2.3	11.9	8	40	7	38	2	20	
5/ 9/81	900	10717.0	2.3	11.9	10	40	9	38	3	20	
5/ 9/81	915	10717.0	2.3	11.9	10	40	9	38	3	20	
5/ 9/81	930	10717.0	2.0	12.0	14	38	13	35	4	19	
5/ 9/81	945	10717.0	2.1	12.0	12	39	11	37	3	20	
5/ 9/81	1000	10717.0	2.0	12.0	13	38	12	35	4	19	
5/ 9/81	1015	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 9/81	1030	10717.0	.0	.0	0	0	0	0	0	0	C
5/ 9/81	1045	10717.0	2.2	11.9	45	46	43	44	14	23	
5/ 9/81	1100	10717.0	1.8	12.4	12	35	11	32	3	17	
5/ 9/81	1115	10717.0	1.6	12.4	19	34	17	31	5	17	
5/ 9/81	1130	10717.0	1.7	12.3	19	34	17	31	5	17	
5/ 9/81	1145	10717.0	1.8	12.2	17	35	15	32	5	17	
5/ 9/81	1200	10717.0	1.7	12.4	20	34	18	31	6	17	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/ 9/81	1215	10717.0	1.5	12.4	21	33	19	30	6	16	
5/ 9/81	1230	10717.0	1.5	12.5	19	33	17	30	5	16	
5/ 9/81	1245	10717.0	1.8	12.5	19	35	17	32	5	17	
5/ 9/81	1300	10717.0	1.6	13.1	19	34	17	31	5	17	
5/ 9/81	1315	10717.0	1.6	12.7	18	33	16	30	5	16	
5/ 9/81	1330	10717.0	1.6	12.5	15	34	13	31	4	17	
5/ 9/81	1345	10717.0	1.5	12.8	14	34	12	31	4	17	
5/ 9/81	1400	10717.0	1.7	12.5	14	35	13	32	4	17	
5/ 9/81	1415	10717.0	1.4	12.6	15	33	13	30	4	16	
5/ 9/81	1430	10717.0	1.7	12.1	14	36	13	33	4	18	
5/ 9/81	1445	10717.0	1.8	11.4	13	36	12	33	4	18	
5/ 9/81	1500	10717.0	1.6	10.3	14	35	12	32	4	17	
5/ 9/81	1515	10717.0	1.8	9.9	12	36	11	33	3	18	
5/ 9/81	1530	10717.0	1.8	11.0	13	36	12	33	4	18	
5/ 9/81	1545	10717.0	1.6	11.3	13	35	12	32	3	17	
5/ 9/81	1600	10717.0	1.8	11.1	14	36	13	33	4	18	
5/ 9/81	1615	10717.0	1.7	11.3	13	35	12	32	3	17	
5/ 9/81	1630	10717.0	1.8	11.3	12	36	11	33	3	18	
5/ 9/81	1645	10717.0	1.3	11.7	12	32	10	29	3	15	
5/ 9/81	1700	10717.0	1.7	11.6	13	35	12	32	3	17	
5/ 9/81	1715	10717.0	1.6	11.6	12	35	11	32	3	17	
5/ 9/81	1730	10717.0	1.6	11.6	11	35	10	32	3	17	
5/ 9/81	1745	10717.0	1.6	11.7	12	35	11	32	3	17	
5/ 9/81	1800	10717.0	1.7	11.6	14	36	13	33	4	18	
5/ 9/81	1815	10717.0	1.2	12.0	14	32	12	29	4	15	
5/ 9/81	1830	10717.0	1.6	11.8	16	34	14	31	4	17	
5/ 9/81	1845	10717.0	1.6	11.8	16	35	14	32	4	17	
5/ 9/81	1900	10717.0	1.4	12.0	16	33	14	30	4	16	
5/ 9/81	1915	10717.0	1.6	11.8	17	34	15	31	5	17	
5/ 9/81	1930	10717.0	1.5	11.7	18	34	16	31	5	17	
5/ 9/81	1945	10717.0	1.5	11.7	17	34	15	31	5	17	
5/ 9/81	2000	10717.0	1.6	11.8	17	35	15	32	5	17	
5/ 9/81	2015	10717.0	1.5	11.8	18	34	16	31	5	17	
5/ 9/81	2030	10717.0	1.7	11.8	18	35	16	32	5	17	
5/ 9/81	2045	10717.0	1.7	11.7	19	34	17	31	5	17	
5/ 9/81	2100	10717.0	1.7	11.7	19	34	17	31	5	17	
5/ 9/81	2115	10717.0	1.7	11.7	19	34	17	31	5	17	
5/ 9/81	2130	10717.0	1.7	11.8	18	33	16	30	5	16	
5/ 9/81	2145	10717.0	1.8	11.7	19	34	17	31	5	17	
5/ 9/81	2200	10717.0	1.9	11.7	19	35	17	32	5	17	
5/ 9/81	2215	10717.0	1.7	11.9	19	33	17	30	5	16	
5/ 9/81	2230	10717.0	2.1	11.7	20	36	19	34	6	18	
5/ 9/81	2245	10717.0	2.1	11.6	19	36	18	34	5	18	
5/ 9/81	2300	10717.0	1.9	11.7	20	35	18	32	6	17	
5/ 9/81	2315	10717.0	2.0	11.6	20	35	18	33	6	17	
5/ 9/81	2330	10717.0	1.8	11.3	20	34	18	31	6	17	
5/ 9/81	2345	10717.0	1.9	11.5	21	35	19	32	6	17	
5/ 9/81	2400	10717.0	2.0	11.4	20	35	18	33	6	17	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/10/81	15	10717.0	1.8	12.2	15	33	14	30	4	16	
5/10/81	30	10717.0	2.0	12.1	14	34	13	32	4	17	
5/10/81	45	10717.0	2.0	12.1	17	35	16	33	5	17	
5/10/81	100	10717.0	1.9	12.1	14	34	13	32	4	17	
5/10/81	115	10717.0	2.0	12.1	16	35	15	33	4	17	
5/10/81	130	10717.0	2.0	12.1	15	35	14	33	4	17	
5/10/81	145	10717.0	1.9	12.1	16	34	15	32	4	17	
5/10/81	200	10717.0	1.8	12.2	14	33	13	30	4	16	
5/10/81	215	10717.0	1.7	12.3	16	32	14	29	4	16	
5/10/81	230	10717.0	1.7	12.3	12	33	11	30	3	16	
5/10/81	245	10717.0	1.8	12.2	10	33	9	30	3	16	
5/10/81	300	10717.0	2.3	11.9	13	37	12	35	4	19	
5/10/81	315	10717.0	1.9	12.1	14	33	13	31	4	16	
5/10/81	330	10717.0	1.7	12.3	14	31	13	28	4	15	
5/10/81	345	10717.0	2.1	12.0	14	35	13	33	4	18	
5/10/81	400	10717.0	1.7	12.3	15	32	13	29	4	16	
5/10/81	415	10717.0	2.0	12.1	13	34	12	32	4	17	
5/10/81	430	10717.0	2.2	11.9	16	35	15	33	5	18	
5/10/81	445	10717.0	2.0	12.1	17	33	16	31	5	16	
5/10/81	500	10717.0	2.2	11.9	13	35	12	33	4	18	
5/10/81	515	10717.0	2.1	12.0	12	35	11	33	3	18	
5/10/81	530	10717.0	2.1	12.0	9	35	8	33	2	18	
5/10/81	545	10717.0	2.0	12.1	9	34	8	32	2	17	
5/10/81	600	10717.0	2.1	12.0	7	35	6	33	2	18	
5/10/81	615	10717.0	2.1	12.0	7	34	6	32	2	17	
5/10/81	630	10717.0	2.1	12.0	8	34	7	32	2	17	
5/10/81	645	10717.0	1.9	12.1	6	33	5	31	1	16	
5/10/81	700	10717.0	1.9	12.1	6	33	5	31	1	16	
5/10/81	715	10717.0	2.0	12.1	4	33	3	31	1	16	
5/10/81	730	10717.0	2.0	12.1	6	33	5	31	1	16	
5/10/81	745	10717.0	1.9	12.1	7	33	6	31	2	16	
5/10/81	800	10717.0	2.5	11.7	5	37	4	35	1	19	
5/10/81	815	10717.0	1.9	12.1	7	33	6	31	2	16	
5/10/81	830	10717.0	1.6	12.3	6	31	5	28	1	15	
5/10/81	845	10717.0	2.1	12.0	5	35	4	33	1	18	
5/10/81	900	10717.0	1.8	12.2	5	32	4	29	1	16	
5/10/81	915	10717.0	2.5	11.7	6	38	5	36	1	20	
5/10/81	930	10717.0	2.1	12.0	5	35	4	33	1	18	
5/10/81	945	10717.0	2.2	11.9	4	36	3	34	1	18	
5/10/81	1000	10717.0	2.2	11.9	5	36	4	34	1	18	
5/10/81	1015	10717.0	2.0	12.1	5	35	4	33	1	17	
5/10/81	1030	10717.0	2.0	12.1	5	36	4	34	1	18	
5/10/81	1045	10717.0	1.7	12.3	5	34	4	31	1	17	
5/10/81	1100	10717.0	.9	12.7	34	27	30	24	10	13	
5/10/81	1115	10717.0	1.8	12.2	5	33	4	30	1	16	
5/10/81	1130	10717.0	1.9	12.1	5	35	4	32	1	17	
5/10/81	1145	10717.0	1.9	12.1	6	35	5	32	1	17	
5/10/81	1200	10717.0	1.9	12.1	7	36	6	33	2	18	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/10/81	1215	10717.0	.0	.0	0	0	0	0	0	0	C
5/10/81	1230	10717.0	2.3	11.9	76	45	73	43	24	23	
5/10/81	1245	10717.0	1.5	12.4	14	32	12	29	4	16	
5/10/81	1300	10717.0	1.8	12.2	14	34	13	31	4	17	
5/10/81	1315	10717.0	1.9	12.1	12	35	11	32	3	17	
5/10/81	1330	10717.0	1.6	12.3	11	33	10	30	3	16	
5/10/81	1345	10717.0	1.2	12.6	11	30	9	27	3	14	
5/10/81	1400	10717.0	1.9	12.1	12	36	11	33	3	18	
5/10/81	1415	10717.0	1.7	12.3	14	34	13	31	4	17	
5/10/81	1430	10717.0	1.4	12.4	16	32	14	29	4	15	
5/10/81	1445	10717.0	1.7	12.3	12	35	11	32	3	17	
5/10/81	1500	10717.0	1.8	12.2	12	35	11	32	3	17	
5/10/81	1515	10717.0	1.2	12.6	13	30	11	27	3	14	
5/10/81	1530	10717.0	1.4	12.4	11	32	10	29	3	15	
5/10/81	1545	10717.0	1.1	12.6	10	30	9	27	2	14	
5/10/81	1600	10717.0	1.1	12.6	11	30	9	27	3	14	
5/10/81	1615	10717.0	1.4	12.4	11	32	10	29	3	15	
5/10/81	1630	10717.0	1.2	12.6	15	30	13	27	4	14	
5/10/81	1645	10717.0	1.4	12.4	13	28	11	25	3	13	
5/10/81	1700	10717.0	1.4	12.4	14	33	12	30	4	16	
5/10/81	1715	10717.0	1.2	12.6	13	29	11	26	3	14	
5/10/81	1730	10717.0	1.3	12.5	12	31	10	28	3	15	
5/10/81	1745	10717.0	1.2	12.6	12	31	10	28	3	15	
5/10/81	1800	10717.0	.9	12.8	19	28	17	25	5	13	
5/10/81	1815	10717.0	.9	12.8	37	28	33	25	10	13	
5/10/81	1830	10717.0	1.0	12.7	15	29	13	26	4	14	
5/10/81	1845	10717.0	1.1	12.6	14	30	12	27	4	14	
5/10/81	1900	10717.0	1.0	12.7	13	29	11	26	3	14	
5/10/81	1915	10717.0	1.6	12.3	12	34	11	31	3	17	
5/10/81	1930	10717.0	.5	13.0	96	23	84	20	27	10	
5/10/81	1945	10717.0	.6	12.9	13	25	11	22	3	11	
5/10/81	2000	10717.0	1.3	12.5	12	30	10	27	3	14	
5/10/81	2015	10717.0	1.1	12.6	12	30	10	27	3	14	
5/10/81	2030	10717.0	1.2	12.6	11	30	9	27	3	14	
5/10/81	2045	10717.0	1.3	12.5	11	32	10	29	3	15	
5/10/81	2100	10717.0	1.3	12.5	12	32	10	29	3	15	
5/10/81	2115	10717.0	1.4	12.4	11	31	10	28	3	15	
5/10/81	2130	10717.0	1.4	12.4	11	31	10	28	3	15	
5/10/81	2145	10717.0	1.4	12.4	12	30	11	27	3	14	
5/10/81	2200	10717.0	1.3	12.5	12	29	10	26	3	14	
5/10/81	2215	10717.0	1.3	12.5	12	29	10	26	3	14	
5/10/81	2230	10717.0	1.1	12.6	12	27	10	24	3	13	
5/10/81	2245	10717.0	1.5	12.4	11	30	10	27	3	15	
5/10/81	2300	10717.0	1.3	12.5	15	28	13	25	4	13	
5/10/81	2315	10717.0	1.2	12.6	20	27	18	24	5	13	
5/10/81	2330	10717.0	1.5	12.4	19	30	17	27	5	15	
5/10/81	2345	10717.0	1.3	12.5	17	29	15	26	5	14	
5/10/81	2400	10717.0	1.4	12.4	16	29	14	26	4	14	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/11/81	15	11271.0	1.4	12.4	16	30	14	27	4	14	
5/11/81	30	11271.0	1.5	12.4	14	30	12	27	4	15	
5/11/81	45	11271.0	1.7	12.3	14	32	13	29	4	16	
5/11/81	100	11271.0	1.6	12.3	21	32	19	29	6	16	
5/11/81	115	11271.0	1.6	12.3	18	31	16	28	5	15	
5/11/81	130	11271.0	1.6	12.3	17	31	15	28	5	15	
5/11/81	145	11271.0	1.6	12.3	18	32	16	29	5	16	
5/11/81	200	11271.0	1.9	12.1	15	34	14	32	4	17	
5/11/81	215	11271.0	1.8	12.2	12	33	11	30	3	16	
5/11/81	230	11271.0	2.2	11.9	11	36	10	34	3	18	
5/11/81	245	11271.0	2.1	12.0	11	35	10	33	3	18	
5/11/81	300	11271.0	1.8	12.2	12	34	11	31	3	17	
5/11/81	315	11271.0	1.9	12.1	13	35	12	32	4	17	
5/11/81	330	11271.0	1.3	12.5	1	29	0	26	0	14	
5/11/81	345	11271.0	2.1	12.0	14	35	13	33	4	18	
5/11/81	400	11271.0	2.2	11.9	10	36	9	34	3	18	
5/11/81	415	11271.0	2.0	12.0	12	34	11	32	3	17	
5/11/81	430	11271.0	2.0	12.0	13	34	12	32	4	17	
5/11/81	445	11271.0	2.2	11.9	12	35	11	33	3	18	
5/11/81	500	11271.0	2.0	12.0	11	34	10	32	3	17	
5/11/81	515	11271.0	2.1	12.0	12	35	11	33	3	18	
5/11/81	530	11271.0	1.9	12.1	13	33	12	31	4	16	
5/11/81	545	11271.0	1.9	12.1	13	33	12	31	4	16	
5/11/81	600	11271.0	1.8	12.2	13	33	12	30	4	16	
5/11/81	615	11271.0	1.9	12.1	15	33	14	31	4	16	
5/11/81	630	11271.0	1.9	12.1	17	33	16	31	5	16	
5/11/81	645	11271.0	1.8	12.2	17	32	15	29	5	16	
5/11/81	700	11271.0	1.8	12.2	14	31	13	29	4	15	
5/11/81	715	11271.0	1.9	12.1	16	33	15	31	4	16	
5/11/81	730	11271.0	2.0	12.0	16	33	15	31	4	16	
5/11/81	745	11271.0	1.7	12.3	19	32	17	29	5	16	
5/11/81	800	11271.0	1.9	12.1	22	33	20	31	6	16	
5/11/81	815	11271.0	1.9	12.1	24	34	22	32	7	17	
5/11/81	830	11271.0	1.5	12.4	25	31	23	28	7	15	
5/11/81	845	11271.0	1.9	12.1	26	34	24	32	8	17	
5/11/81	900	11271.0	2.1	12.0	22	35	20	33	6	18	
5/11/81	915	11271.0	2.0	12.0	24	35	22	33	7	17	
5/11/81	930	11271.0	2.0	12.0	22	35	20	33	6	17	
5/11/81	945	11271.0	1.9	12.1	23	34	21	32	7	17	
5/11/81	1000	11271.0	1.8	12.2	22	33	20	30	6	16	
5/11/81	1015	11271.0	.0	.0	0	0	0	0	0	0	C
5/11/81	1030	11271.0	.0	.0	0	0	0	0	0	0	I
5/11/81	1045	11271.0	.0	.0	0	0	0	0	0	0	I
5/11/81	1100	11271.0	1.8	12.2	3	36	2	33	0	18	
5/11/81	1115	11271.0	1.5	12.4	2	33	1	30	0	16	
5/11/81	1130	11271.0	1.6	12.3	0	34	0	31	0	17	
5/11/81	1145	11271.0	1.7	12.3	2	35	1	32	0	17	
5/11/81	1200	11271.0	1.4	12.4	2	33	1	30	0	16	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/11/81	1215	11271.0	1.4	12.4	4	33	3	30	1	16	
5/11/81	1230	11271.0	.0	.0	0	0	0	0	0	0	C
5/11/81	1245	11271.0	1.4	12.4	3	70	2	64	0	34	
5/11/81	1300	11271.0	1.4	12.4	2	32	1	29	0	15	
5/11/81	1315	11271.0	1.5	12.4	1	33	0	30	0	16	
5/11/81	1330	11271.0	1.4	12.4	0	33	0	30	0	16	
5/11/81	1345	11271.0	1.5	12.4	0	33	0	30	0	16	
5/11/81	1400	11271.0	1.5	12.4	6	32	5	29	1	16	
5/11/81	1415	11271.0	1.1	12.6	8	31	7	28	2	15	
5/11/81	1430	11271.0	1.5	12.4	8	32	7	29	2	16	
5/11/81	1445	11271.0	1.4	12.4	10	31	9	28	3	15	
5/11/81	1500	11271.0	1.5	12.4	10	32	9	29	3	16	
5/11/81	1515	11271.0	1.6	12.6	10	32	9	29	3	16	
5/11/81	1530	11271.0	1.4	12.4	10	31	9	28	3	15	
5/11/81	1545	11271.0	1.6	12.6	9	33	8	30	2	16	
5/11/81	1600	11271.0	1.4	12.4	9	32	8	29	2	15	
5/11/81	1615	11271.0	1.5	12.4	4	32	3	29	1	16	
5/11/81	1630	11271.0	1.4	12.4	6	31	5	28	1	15	
5/11/81	1645	11271.0	.3	13.2	1283	12	1114	10	366	5	
5/11/81	1700	11271.0	.1	13.3	1486	14	1278	12	420	6	
5/11/81	1715	11271.0	.6	12.9	16	25	14	22	4	11	
5/11/81	1730	11271.0	1.2	12.6	16	29	14	26	4	14	
5/11/81	1745	11271.0	1.4	12.4	14	33	12	30	4	16	
5/11/81	1800	11271.0	1.3	12.5	8	31	7	28	2	15	
5/11/81	1815	11271.0	1.4	12.4	10	32	9	29	3	15	
5/11/81	1830	11271.0	1.3	12.5	10	30	9	27	3	14	
5/11/81	1845	11271.0	1.1	12.6	13	29	11	26	3	14	
5/11/81	1900	11271.0	1.3	12.5	10	31	9	28	3	15	
5/11/81	1915	11271.0	1.2	12.6	10	29	9	26	2	14	
5/11/81	1930	11271.0	1.3	12.5	10	30	9	27	3	14	
5/11/81	1945	11271.0	1.3	12.5	11	30	10	27	3	14	
5/11/81	2000	11271.0	1.3	12.5	9	31	8	28	2	15	
5/11/81	2015	10717.0	1.3	12.5	10	30	9	27	3	14	
5/11/81	2030	10717.0	1.4	12.4	10	31	9	28	3	15	
5/11/81	2045	10717.0	1.2	12.6	8	29	7	26	2	14	
5/11/81	2100	10717.0	1.2	12.6	10	28	9	25	2	13	
5/11/81	2115	10717.0	1.3	12.5	9	29	8	26	2	14	
5/11/81	2130	10717.0	1.3	12.5	9	30	8	27	2	14	
5/11/81	2145	10717.0	1.5	12.4	9	31	8	28	2	15	
5/11/81	2200	10717.0	1.4	12.4	8	30	7	27	2	14	
5/11/81	2215	10717.0	1.4	12.4	8	31	7	28	2	15	
5/11/81	2230	10717.0	1.5	12.4	7	31	6	28	2	15	
5/11/81	2245	10717.0	1.5	12.4	8	31	7	28	2	15	
5/11/81	2300	10717.0	1.4	12.4	7	30	6	27	2	14	
5/11/81	2315	10717.0	1.5	12.4	8	31	7	28	2	15	
5/11/81	2330	10717.0	1.6	12.3	8	31	7	28	2	15	
5/11/81	2345	10717.0	1.6	12.3	8	30	7	27	2	15	
5/11/81	2400	10717.0	1.6	12.3	8	30	7	27	2	15	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/12/81	15	10717.0	1.6	12.3	8	30	7	27	2	15	
5/12/81	30	10717.0	1.6	12.3	10	29	9	26	3	14	
5/12/81	45	10717.0	1.6	12.3	10	29	9	26	3	14	
5/12/81	100	10717.0	1.6	12.3	10	31	9	28	3	15	
5/12/81	115	10717.0	1.4	12.4	10	29	9	26	3	14	
5/12/81	130	10717.0	1.7	12.3	9	32	8	29	2	16	
5/12/81	145	10717.0	1.6	12.3	9	31	8	28	2	15	
5/12/81	200	10717.0	1.6	12.3	9	31	8	28	2	15	
5/12/81	215	10717.0	1.6	12.3	9	31	8	28	2	15	
5/12/81	230	10717.0	1.6	12.3	9	31	8	28	2	15	
5/12/81	245	10717.0	1.9	12.1	8	33	7	31	2	16	
5/12/81	300	10717.0	1.7	12.3	13	31	12	28	3	15	
5/12/81	315	10717.0	1.7	12.3	12	31	11	28	3	15	
5/12/81	330	10717.0	1.9	12.1	10	32	9	30	3	16	
5/12/81	345	10717.0	1.8	12.2	14	32	13	29	4	16	
5/12/81	400	10717.0	1.9	12.1	16	31	15	29	4	15	
5/12/81	415	10717.0	1.8	12.2	15	32	14	29	4	16	
5/12/81	430	10717.0	1.9	12.1	14	32	13	30	4	16	
5/12/81	445	10717.0	1.9	12.1	14	31	13	29	4	15	
5/12/81	500	10717.0	1.8	12.2	13	30	12	28	4	15	
5/12/81	515	10717.0	1.7	12.3	12	31	11	28	3	15	
5/12/81	530	10717.0	1.7	12.3	12	30	11	27	3	15	
5/12/81	545	10717.0	1.7	12.3	11	30	10	27	3	15	
5/12/81	600	10717.0	1.8	12.2	11	30	10	28	3	15	
5/12/81	615	10717.0	1.7	12.3	12	30	11	27	3	15	
5/12/81	630	10717.0	1.7	12.3	10	30	9	27	3	15	
5/12/81	645	10717.0	1.7	12.3	10	30	9	27	3	15	
5/12/81	700	10717.0	1.7	12.3	10	31	9	28	3	15	
5/12/81	715	10717.0	1.8	12.2	12	31	11	29	3	15	
5/12/81	730	10717.0	1.6	12.3	12	30	11	27	3	15	
5/12/81	745	10717.0	1.6	12.3	9	30	8	27	2	15	
5/12/81	800	10717.0	1.6	12.3	10	30	9	27	3	15	
5/12/81	815	10717.0	1.5	12.4	12	30	11	27	3	15	
5/12/81	830	10717.0	1.6	12.3	13	30	12	27	3	15	
5/12/81	845	10717.0	1.6	12.3	13	30	12	27	3	15	
5/12/81	900	10717.0	1.5	12.4	11	30	10	27	3	15	
5/12/81	915	10717.0	1.7	12.3	9	32	8	29	2	16	
5/12/81	930	10717.0	1.5	12.4	10	31	9	28	3	15	
5/12/81	945	10717.0	1.5	12.4	10	31	9	28	3	15	
5/12/81	1000	10717.0	1.5	12.4	9	31	8	28	2	15	
5/12/81	1015	10717.0	1.7	12.3	9	31	8	28	2	15	
5/12/81	1030	10717.0	1.7	12.3	8	32	7	29	2	16	
5/12/81	1045	10717.0	1.7	12.3	7	32	6	29	2	16	
5/12/81	1100	10717.0	1.5	12.4	7	31	6	28	2	15	
5/12/81	1115	10717.0	1.3	12.5	13	28	11	25	3	13	
5/12/81	1130	10717.0	1.4	12.4	14	30	12	27	4	14	
5/12/81	1145	10717.0	1.2	12.6	13	29	11	26	3	14	
5/12/81	1200	10717.0	1.3	12.5	11	30	10	27	3	14	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/12/81	1215	10717.0	1.2	12.6	13	29	11	26	3	14	
5/12/81	1230	10717.0	1.1	12.6	16	28	14	25	4	13	
5/12/81	1245	10717.0	1.1	12.6	16	29	14	26	4	14	
5/12/81	1300	10717.0	1.2	12.6	15	30	13	27	4	14	
5/12/81	1315	10717.0	1.2	12.6	15	29	13	26	4	14	
5/12/81	1330	10717.0	1.3	12.5	11	31	10	28	3	15	
5/12/81	1345	10717.0	1.3	12.5	12	31	10	28	3	15	
5/12/81	1400	10717.0	1.1	12.6	16	31	14	28	4	15	
5/12/81	1415	10717.0	1.2	12.6	19	30	17	27	5	14	
5/12/81	1430	10717.0	1.8	12.2	15	51	14	47	4	25	
5/12/81	1445	10717.0	1.2	12.6	6	29	5	26	1	14	
5/12/81	1500	10717.0	1.1	12.6	7	30	6	27	2	14	
5/12/81	1515	10717.0	1.3	12.5	7	32	6	29	2	15	
5/12/81	1530	10717.0	1.3	12.5	7	32	6	29	2	15	
5/12/81	1545	10717.0	1.1	12.6	8	30	7	27	2	14	
5/12/81	1600	10717.0	1.1	12.6	8	31	7	28	2	15	
5/12/81	1615	10717.0	1.3	12.5	7	32	6	29	2	15	
5/12/81	1630	10717.0	1.1	12.6	1	29	0	26	0	14	
5/12/81	1645	10717.0	1.1	12.6	6	30	5	27	1	14	
5/12/81	1700	10717.0	1.2	12.6	6	31	5	28	1	15	
5/12/81	1715	10717.0	1.1	12.6	6	30	5	27	1	14	
5/12/81	1730	10717.0	1.0	12.7	2	28	1	25	0	13	
5/12/81	1745	10717.0	1.0	12.7	2	30	1	26	0	14	
5/12/81	1800	10717.0	1.0	12.7	1	28	0	25	0	13	
5/12/81	1815	10717.0	1.0	12.7	2	28	1	25	0	13	
5/12/81	1830	10717.0	1.0	12.7	3	30	2	26	0	14	
5/12/81	1845	10717.0	1.2	12.6	4	31	3	28	1	15	
5/12/81	1900	10717.0	1.0	12.7	9	30	8	26	2	14	
5/12/81	1915	10717.0	1.0	12.7	10	29	8	26	2	14	
5/12/81	1930	10717.0	1.1	12.6	7	30	6	27	2	14	
5/12/81	1945	10717.0	1.2	12.6	8	30	7	27	2	14	
5/12/81	2000	10717.0	1.1	12.6	5	31	4	28	1	15	
5/12/81	2015	10717.0	1.3	12.5	1	30	0	27	0	14	
5/12/81	2030	10717.0	1.3	12.5	0	31	0	28	0	15	
5/12/81	2045	10717.0	1.3	12.5	0	31	0	28	0	15	
5/12/81	2100	10717.0	1.5	12.4	0	30	0	27	0	15	
5/12/81	2115	10717.0	1.3	12.5	2	31	1	28	0	15	
5/12/81	2130	10717.0	1.5	12.4	6	32	5	29	1	16	
5/12/81	2145	10717.0	1.3	12.5	11	30	10	27	3	14	
5/12/81	2200	10717.0	1.4	12.4	11	31	10	28	3	15	
5/12/81	2215	10717.0	1.3	12.5	11	30	10	27	3	14	
5/12/81	2230	10717.0	1.3	12.5	6	30	5	27	1	14	
5/12/81	2245	10717.0	1.7	12.3	8	33	7	30	2	16	
5/12/81	2300	10717.0	1.3	12.5	6	30	5	27	1	14	
5/12/81	2315	10717.0	1.7	12.3	8	33	7	30	2	16	
5/12/81	2330	10717.0	1.6	12.3	8	32	7	29	2	16	
5/12/81	2345	10717.0	1.6	12.3	3	33	2	30	0	16	
5/12/81	2400	10717.0	1.7	12.3	8	33	7	30	2	16	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/13/81	15	10717.0	1.6	12.3	0	32	0	29	0	16	
5/13/81	30	10717.0	1.6	12.3	0	32	0	29	0	16	
5/13/81	45	10717.0	1.6	12.3	0	33	0	30	0	16	
5/13/81	100	10717.0	1.8	12.2	0	34	0	31	0	17	
5/13/81	115	10717.0	1.7	12.3	0	34	0	31	0	17	
5/13/81	130	10717.0	1.7	12.3	0	34	0	31	0	17	
5/13/81	145	10717.0	1.7	12.3	0	34	0	31	0	17	
5/13/81	200	10717.0	1.8	12.2	0	33	0	30	0	16	
5/13/81	215	10717.0	1.8	12.2	0	34	0	31	0	17	
5/13/81	230	10717.0	1.7	12.3	0	33	0	30	0	16	
5/13/81	245	10717.0	1.7	12.3	0	33	0	30	0	16	
5/13/81	300	10717.0	1.6	12.3	0	32	0	29	0	16	
5/13/81	315	10717.0	1.7	12.3	0	34	0	31	0	17	
5/13/81	330	10717.0	1.8	12.2	2	35	1	32	0	17	
5/13/81	345	10717.0	1.8	12.2	3	35	2	32	0	17	
5/13/81	400	10717.0	1.8	12.2	3	35	2	32	0	17	
5/13/81	415	10717.0	1.8	12.2	4	34	3	31	1	17	
5/13/81	430	10717.0	1.9	12.1	4	35	3	32	1	17	
5/13/81	445	10717.0	1.9	12.1	4	34	3	32	1	17	
5/13/81	500	10717.0	.0	.0	0	0	0	0	0	0	C
5/13/81	515	10717.0	.0	.0	0	0	0	0	0	0	C
5/13/81	530	10717.0	.0	.0	0	0	0	0	0	0	C
5/13/81	545	10717.0	.0	.0	0	0	0	0	0	0	C
5/13/81	600	10717.0	.0	.0	0	0	0	0	0	0	C
5/13/81	615	10717.0	2.0	12.0	5	35	4	33	1	17	
5/13/81	630	10717.0	1.9	12.1	5	35	4	32	1	17	
5/13/81	645	10717.0	1.9	12.1	5	34	4	32	1	17	
5/13/81	700	10717.0	2.0	12.0	5	35	4	33	1	17	
5/13/81	715	10717.0	.0	.0	0	0	0	0	0	0	C
5/13/81	730	10717.0	2.0	12.0	8	46	7	43	2	23	
5/13/81	745	10717.0	2.0	12.0	6	37	5	35	1	19	
5/13/81	800	10717.0	1.7	12.3	7	36	6	33	2	18	
5/13/81	815	10717.0	1.8	12.2	8	36	7	33	2	18	
5/13/81	830	10717.0	1.9	12.1	7	34	6	32	2	17	
5/13/81	845	10717.0	1.9	12.1	7	34	6	32	2	17	
5/13/81	900	10717.0	2.0	12.0	7	35	6	33	2	17	
5/13/81	915	10717.0	.0	.0	0	0	0	0	0	0	I
5/13/81	930	10717.0	.0	.0	0	0	0	0	0	0	I
5/13/81	945	10717.0	1.9	12.1	5	35	4	32	1	17	
5/13/81	1000	10717.0	2.0	12.0	6	35	5	33	1	17	
5/13/81	1015	10717.0	1.8	12.2	5	33	4	30	1	16	
5/13/81	1030	10717.0	1.8	12.2	5	33	4	30	1	16	
5/13/81	1045	10717.0	1.7	12.3	5	32	4	29	1	16	
5/13/81	1100	10717.0	1.5	12.3	6	31	5	28	1	15	
5/13/81	1115	10717.0	1.5	12.3	6	32	5	29	1	16	
5/13/81	1130	10717.0	2.0	12.0	6	35	5	33	1	17	
5/13/81	1145	10717.0	1.6	12.2	6	32	5	29	1	16	
5/13/81	1200	10717.0	1.6	12.2	5	32	4	29	1	16	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/13/81	1215	10717.0	1.6	12.2	5	32	4	29	1	16	
5/13/81	1230	10717.0	1.5	12.3	7	31	6	28	2	15	
5/13/81	1245	10717.0	1.6	12.2	6	32	5	29	1	16	
5/13/81	1300	10717.0	1.6	12.2	5	30	4	27	1	15	
5/13/81	1315	10717.0	1.5	12.3	5	31	4	28	1	15	
5/13/81	1330	10717.0	1.6	12.2	5	31	4	28	1	15	
5/13/81	1345	10717.0	1.6	12.2	6	31	5	28	1	15	
5/13/81	1400	10717.0	1.5	12.3	6	30	5	27	1	15	
5/13/81	1415	10717.0	1.5	12.2	6	31	5	28	1	15	
5/13/81	1430	10717.0	1.3	12.3	7	29	6	26	2	14	
5/13/81	1445	10717.0	1.5	12.2	7	29	6	26	2	14	
5/13/81	1500	10717.0	1.4	12.3	7	29	6	26	2	14	
5/13/81	1515	10717.0	1.5	12.3	6	30	5	27	1	15	
5/13/81	1530	10717.0	1.5	12.2	5	31	4	28	1	15	
5/13/81	1545	10717.0	1.4	12.3	5	30	4	27	1	14	
5/13/81	1600	10717.0	1.3	12.4	5	29	4	26	1	14	
5/13/81	1615	10717.0	1.4	12.3	6	30	5	27	1	14	
5/13/81	1630	10717.0	1.4	12.3	5	30	4	27	1	14	
5/13/81	1645	10717.0	1.3	12.3	6	28	5	25	1	13	
5/13/81	1700	10717.0	1.6	12.2	5	31	4	28	1	15	
5/13/81	1715	10717.0	1.6	12.2	5	30	4	27	1	15	
5/13/81	1730	10717.0	1.7	12.1	5	32	4	29	1	16	
5/13/81	1745	10717.0	1.6	12.1	5	32	4	29	1	16	
5/13/81	1800	10717.0	1.7	12.1	4	31	3	28	1	15	
5/13/81	1815	10717.0	1.7	12.1	2	32	1	29	0	16	
5/13/81	1830	10717.0	1.7	12.1	1	32	0	29	0	16	
5/13/81	1845	10717.0	1.8	12.2	1	33	0	30	0	16	
5/13/81	1900	10717.0	1.7	12.3	1	31	0	28	0	15	
5/13/81	1915	10717.0	1.7	12.3	1	32	0	29	0	16	
5/13/81	1930	10717.0	1.7	12.3	6	31	5	28	1	15	
5/13/81	1945	10717.0	1.6	12.3	5	30	4	27	1	15	
5/13/81	2000	10717.0	1.8	12.2	5	31	4	29	1	15	
5/13/81	2015	10717.0	1.8	12.2	4	31	3	29	1	15	
5/13/81	2030	10717.0	1.9	12.1	4	32	3	30	1	16	
5/13/81	2045	10717.0	2.0	12.0	4	32	3	30	1	16	
5/13/81	2100	10717.0	2.0	12.0	4	33	3	31	1	16	
5/13/81	2115	10717.0	1.7	12.3	5	31	4	28	1	15	
5/13/81	2130	10717.0	1.6	12.3	5	30	4	27	1	15	
5/13/81	2145	10717.0	1.7	12.3	5	31	4	28	1	15	
5/13/81	2200	10717.0	.0	.0	0	0	0	0	0	0	K
5/13/81	2215	10717.0	1.6	12.3	5	30	4	27	1	15	
5/13/81	2230	10717.0	.0	.0	0	0	0	0	0	0	K
5/13/81	2245	10717.0	1.9	12.1	11	33	10	31	3	16	
5/13/81	2300	10717.0	1.9	12.1	7	33	6	31	2	16	
5/13/81	2315	10717.0	1.9	12.1	6	32	5	30	1	16	
5/13/81	2330	10717.0	1.9	12.1	5	33	4	31	1	16	
5/13/81	2345	10717.0	2.0	12.0	5	33	4	31	1	16	
5/13/81	2400	10717.0	.0	.0	0	0	0	0	0	0	K

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/14/81	15	10717.0	2.0	12.0	1	33	0	31	0	16	
5/14/81	30	10717.0	2.0	12.0	0	33	0	31	0	16	
5/14/81	45	10717.0	1.8	12.2	0	33	0	30	0	16	
5/14/81	100	10717.0	1.9	12.1	0	33	0	31	0	16	
5/14/81	115	10717.0	1.9	12.1	0	34	0	32	0	17	
5/14/81	130	10717.0	2.0	12.0	0	34	0	32	0	17	
5/14/81	145	10717.0	2.0	12.0	0	33	0	31	0	16	
5/14/81	200	10717.0	2.0	12.0	0	33	0	31	0	16	
5/14/81	215	10717.0	2.0	12.0	4	33	3	31	1	16	
5/14/81	230	10717.0	1.9	12.1	3	32	2	30	0	16	
5/14/81	245	10717.0	1.9	12.1	4	32	3	30	1	16	
5/14/81	300	10717.0	2.0	12.0	4	34	3	32	1	17	
5/14/81	315	10717.0	1.9	12.1	5	33	4	31	1	16	
5/14/81	330	10717.0	2.0	12.0	3	33	2	31	0	16	
5/14/81	345	10717.0	2.0	12.0	3	33	2	31	0	16	
5/14/81	400	10717.0	2.0	12.0	1	34	0	32	0	17	
5/14/81	415	10717.0	2.0	12.0	4	33	3	31	1	16	
5/14/81	430	10717.0	2.0	12.0	5	33	4	31	1	16	
5/14/81	445	10717.0	2.0	12.0	5	33	4	31	1	16	
5/14/81	500	10717.0	2.1	12.0	5	33	4	31	1	17	
5/14/81	515	10717.0	2.1	12.0	5	33	4	31	1	17	
5/14/81	530	10717.0	2.0	12.0	5	34	4	32	1	17	
5/14/81	545	10717.0	2.0	12.0	5	34	4	32	1	17	
5/14/81	600	10717.0	2.0	12.0	6	34	5	32	1	17	
5/14/81	615	10717.0	2.2	11.9	5	34	4	32	1	17	
5/14/81	630	10717.0	.0	.0	0	0	0	0	0	0	C
5/14/81	645	10717.0	.0	.0	0	0	0	0	0	0	C
5/14/81	700	10717.0	2.0	12.0	8	35	7	33	2	17	
5/14/81	715	10717.0	2.0	11.9	7	36	6	34	2	18	
5/14/81	730	10717.0	2.0	11.9	7	36	6	34	2	18	
5/14/81	745	10717.0	2.0	11.8	5	36	4	34	1	18	
5/14/81	800	10717.0	2.0	11.8	5	37	4	35	1	19	
5/14/81	815	10717.0	2.0	11.9	4	36	3	34	1	18	
5/14/81	830	10717.0	2.0	11.9	4	36	3	34	1	18	
5/14/81	845	10717.0	1.8	12.0	4	35	3	32	1	17	
5/14/81	900	10717.0	2.0	11.9	4	37	3	35	1	19	
5/14/81	915	10717.0	1.8	12.1	6	35	5	32	1	17	
5/14/81	930	10717.0	2.0	11.9	6	37	5	35	1	19	
5/14/81	945	10717.0	2.1	11.9	6	38	5	36	1	19	
5/14/81	1000	10717.0	2.1	11.9	5	38	4	36	1	19	
5/14/81	1015	10717.0	2.2	11.9	5	38	4	36	1	19	
5/14/81	1030	10717.0	1.5	12.3	6	33	5	30	1	16	
5/14/81	1045	10717.0	1.6	12.2	5	33	4	30	1	16	
5/14/81	1100	10717.0	2.0	11.8	4	38	3	35	1	19	
5/14/81	1115	10717.0	2.0	11.7	3	37	2	35	0	19	
5/14/81	1130	10717.0	1.9	11.9	1	36	0	33	0	18	
5/14/81	1145	10717.0	1.8	12.0	1	36	0	33	0	18	
5/14/81	1200	10717.0	1.8	12.0	1	37	0	34	0	18	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/14/81	1215	10717.0	1.8	12.0	1	36	0	33	0	18	
5/14/81	1230	10717.0	1.5	12.2	1	33	0	30	0	16	
5/14/81	1245	10717.0	1.8	11.9	1	37	0	34	0	18	
5/14/81	1300	10717.0	2.5	11.9	81	36	78	35	25	18	
5/14/81	1315	10717.0	1.9	12.0	14	36	13	33	4	18	
5/14/81	1330	10717.0	1.5	12.2	15	34	13	31	4	17	
5/14/81	1345	10717.0	1.4	12.3	16	32	14	29	4	15	
5/14/81	1400	10717.0	1.5	12.2	15	33	13	30	4	16	
5/14/81	1415	10717.0	1.3	12.3	15	31	13	28	4	15	
5/14/81	1430	10717.0	1.2	12.4	16	31	14	28	4	15	
5/14/81	1445	10717.0	1.3	12.3	14	32	12	29	4	15	
5/14/81	1500	10717.0	1.0	12.5	17	30	15	26	5	14	
5/14/81	1515	10717.0	1.1	12.4	13	30	11	27	3	14	
5/14/81	1530	10717.0	1.1	12.4	12	30	10	27	3	14	
5/14/81	1545	10717.0	1.0	12.4	13	30	11	26	3	14	
5/14/81	1600	10717.0	1.0	12.6	40	26	35	23	11	12	
5/14/81	1615	10717.0	1.1	12.3	12	30	10	27	3	14	
5/14/81	1630	10717.0	1.1	12.4	13	29	11	26	3	14	
5/14/81	1645	10717.0	1.0	12.5	20	27	17	24	5	13	
5/14/81	1700	10717.0	1.0	12.6	42	25	37	22	12	12	
5/14/81	1715	10717.0	1.1	12.4	14	29	12	26	4	14	
5/14/81	1730	10717.0	1.1	12.4	14	30	12	27	4	14	
5/14/81	1745	10717.0	1.1	12.4	19	30	17	27	5	14	
5/14/81	1800	10717.0	1.1	12.4	17	29	15	26	5	14	
5/14/81	1815	10717.0	1.1	12.4	16	30	14	27	4	14	
5/14/81	1830	10717.0	1.2	12.3	14	30	12	27	4	14	
5/14/81	1845	10717.0	1.3	12.2	14	32	12	29	4	15	
5/14/81	1900	10717.0	1.3	12.2	14	31	12	28	4	15	
5/14/81	1915	10717.0	1.1	12.5	16	31	14	28	4	15	
5/14/81	1930	10717.0	1.3	12.5	15	32	13	29	4	15	
5/14/81	1945	10717.0	1.3	12.6	15	32	13	29	4	15	
5/14/81	2000	10717.0	1.4	12.5	19	33	17	30	5	16	
5/14/81	2015	10717.0	1.3	12.6	17	33	15	30	5	16	
5/14/81	2030	10717.0	1.0	12.8	28	29	25	26	8	14	
5/14/81	2045	10717.0	1.0	12.8	25	30	22	26	7	14	
5/14/81	2100	10717.0	1.2	12.6	19	30	17	27	5	14	
5/14/81	2115	10717.0	1.3	12.6	18	32	16	29	5	15	
5/14/81	2130	10717.0	1.3	12.7	19	32	17	29	5	15	
5/14/81	2145	10717.0	1.5	12.5	19	33	17	30	5	16	
5/14/81	2200	10717.0	1.5	12.4	18	33	16	30	5	16	
5/14/81	2215	10717.0	1.3	12.6	18	31	16	28	5	15	
5/14/81	2230	10717.0	1.4	12.5	18	33	16	30	5	16	
5/14/81	2245	10717.0	1.4	12.5	18	34	16	31	5	16	
5/14/81	2300	10717.0	1.3	12.7	18	32	16	29	5	15	
5/14/81	2315	10717.0	1.3	12.7	18	33	16	30	5	16	
5/14/81	2330	10717.0	1.5	12.5	17	35	15	32	5	17	
5/14/81	2345	10717.0	1.7	12.5	18	36	16	33	5	18	
5/14/81	2400	10717.0	1.7	12.4	18	36	16	33	5	18	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/15/81	15	10717.0	1.7	12.4	17	36	15	33	5	18	
5/15/81	30	10717.0	1.9	12.3	17	37	16	34	5	18	
5/15/81	45	10717.0	1.7	12.4	18	35	16	32	5	17	
5/15/81	100	10717.0	1.7	12.4	18	36	16	33	5	18	
5/15/81	115	10717.0	1.7	11.9	19	35	17	32	5	17	
5/15/81	130	10717.0	1.7	11.8	18	36	16	33	5	18	
5/15/81	145	10717.0	1.7	11.8	17	35	15	32	5	17	
5/15/81	200	10717.0	1.8	11.8	16	37	14	34	4	18	
5/15/81	215	10717.0	1.8	11.8	17	37	15	34	5	18	
5/15/81	230	10717.0	2.0	11.6	17	39	16	36	5	20	
5/15/81	245	10717.0	1.8	11.8	17	37	15	34	5	18	
5/15/81	300	10717.0	2.0	11.6	18	39	17	36	5	20	
5/15/81	315	10717.0	1.9	11.7	18	39	16	36	5	19	
5/15/81	330	10717.0	1.9	11.7	18	38	16	35	5	19	
5/15/81	345	10717.0	1.9	11.7	19	39	17	36	5	19	
5/15/81	400	10717.0	2.2	11.5	19	40	18	38	5	20	
5/15/81	415	10717.0	2.3	11.4	18	40	17	38	5	20	
5/15/81	430	10717.0	2.3	11.4	18	41	17	39	5	21	
5/15/81	445	10717.0	2.2	11.4	19	39	18	37	5	20	
5/15/81	500	10717.0	2.1	11.5	19	38	18	36	5	19	
5/15/81	515	10717.0	2.0	11.6	17	37	16	35	5	19	
5/15/81	530	10717.0	2.0	11.5	18	39	17	36	5	20	
5/15/81	545	10717.0	2.1	11.5	18	40	17	38	5	20	
5/15/81	600	10717.0	2.0	11.6	18	39	17	36	5	20	
5/15/81	615	10717.0	1.9	11.7	17	38	16	35	5	19	
5/15/81	630	10717.0	2.0	12.0	17	39	16	36	5	20	
5/15/81	645	10717.0	1.9	12.1	18	37	16	34	5	18	
5/15/81	700	10717.0	2.0	12.9	9	34	8	32	2	17	
5/15/81	715	10717.0	1.8	12.2	2	39	1	36	0	19	
5/15/81	730	10717.0	.0	.0	0	0	0	0	0	0	C
5/15/81	745	10717.0	1.9	12.9	10	34	9	32	3	17	
5/15/81	800	10717.0	2.0	12.8	10	35	9	33	3	17	
5/15/81	815	10717.0	1.8	13.0	10	34	9	31	3	17	
5/15/81	830	10717.0	1.9	12.9	9	34	8	32	2	17	
5/15/81	845	10717.0	1.1	12.4	10	31	9	28	2	15	
5/15/81	900	10717.0	2.2	12.3	17	38	16	36	5	19	
5/15/81	915	10717.0	2.2	12.3	17	38	16	36	5	19	
5/15/81	930	10717.0	2.1	11.8	11	37	10	35	3	19	
5/15/81	945	10717.0	2.0	11.9	10	37	9	35	3	19	
5/15/81	1000	10717.0	1.9	12.0	8	36	7	33	2	18	
5/15/81	1015	10717.0	2.1	11.8	6	37	5	35	1	19	
5/15/81	1030	10717.0	1.8	12.0	8	34	7	31	2	17	
5/15/81	1045	10717.0	1.9	12.0	10	35	9	32	3	17	
5/15/81	1100	10717.0	1.9	12.0	10	35	9	32	3	17	
5/15/81	1115	10717.0	1.8	12.0	9	35	8	32	2	17	
5/15/81	1130	10717.0	1.8	12.0	8	30	7	28	2	15	
5/15/81	1145	10717.0	1.6	12.1	8	32	7	29	2	16	
5/15/81	1200	10717.0	1.8	12.0	8	34	7	31	2	17	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/15/81	1215	10717.0	1.7	12.0	8	33	7	30	2	16	
5/15/81	1230	10717.0	1.8	12.0	7	33	6	30	2	16	
5/15/81	1245	10717.0	1.6	12.2	8	32	7	29	2	16	
5/15/81	1300	10717.0	1.5	12.2	10	30	9	27	3	15	
5/15/81	1315	10717.0	1.8	12.0	10	33	9	30	3	16	
5/15/81	1330	10717.0	1.7	12.1	11	32	10	29	3	16	
5/15/81	1345	10717.0	1.6	12.1	11	31	10	28	3	15	
5/15/81	1400	10717.0	1.6	12.2	11	30	10	27	3	15	
5/15/81	1415	10717.0	1.5	12.2	11	30	10	27	3	15	
5/15/81	1430	10717.0	1.5	12.2	11	30	10	27	3	15	
5/15/81	1445	10717.0	1.5	12.2	11	29	10	26	3	14	
5/15/81	1500	10717.0	1.5	11.8	5	26	4	23	1	13	
5/15/81	1515	10717.0	1.4	12.3	10	29	9	26	3	14	
5/15/81	1530	10717.0	1.3	12.3	14	28	12	25	4	13	
5/15/81	1545	10717.0	1.3	12.3	10	29	9	26	3	14	
5/15/81	1600	10717.0	1.5	12.1	8	30	7	27	2	15	
5/15/81	1615	10717.0	1.1	12.3	9	27	8	24	2	13	
5/15/81	1630	10717.0	1.3	12.2	7	28	6	25	2	13	
5/15/81	1645	10717.0	1.2	12.3	7	28	6	25	2	13	
5/15/81	1700	10717.0	1.3	12.2	11	28	10	25	3	13	
5/15/81	1715	10717.0	1.1	12.4	13	26	11	23	3	12	
5/15/81	1730	10717.0	1.1	12.4	13	26	11	23	3	12	
5/15/81	1745	10717.0	1.1	12.4	11	26	9	23	3	12	
5/15/81	1800	10717.0	1.0	12.4	12	26	10	23	3	12	
5/15/81	1815	10717.0	1.0	12.4	13	26	11	23	3	12	
5/15/81	1830	10717.0	.8	12.5	14	24	12	21	4	11	
5/15/81	1845	10717.0	1.0	12.4	28	25	25	22	8	12	
5/15/81	1900	10717.0	.7	12.6	54	24	47	21	15	11	
5/15/81	1915	10717.0	.9	12.5	14	25	12	22	4	12	
5/15/81	1930	10717.0	.9	12.5	15	25	13	22	4	12	
5/15/81	1945	10717.0	1.0	12.4	12	27	10	24	3	13	
5/15/81	2000	10717.0	1.0	12.4	11	27	9	24	3	13	
5/15/81	2015	10717.0	1.0	12.4	12	26	10	23	3	12	
5/15/81	2030	10717.0	1.0	12.4	11	27	9	24	3	13	
5/15/81	2045	10717.0	1.1	12.3	11	27	9	24	3	13	
5/15/81	2100	10717.0	1.1	12.3	11	27	9	24	3	13	
5/15/81	2115	10717.0	1.2	12.3	11	27	9	24	3	13	
5/15/81	2130	10717.0	1.4	12.2	10	29	9	26	3	14	
5/15/81	2145	10717.0	1.4	12.2	10	29	9	26	3	14	
5/15/81	2200	10717.0	1.5	12.1	9	30	8	27	2	15	
5/15/81	2215	10717.0	1.3	12.2	10	28	9	25	3	13	
5/15/81	2230	10717.0	1.3	12.2	9	29	8	26	2	14	
5/15/81	2245	10717.0	1.3	12.2	8	29	7	26	2	14	
5/15/81	2300	10717.0	1.2	12.3	9	28	8	25	2	13	
5/15/81	2315	10717.0	1.2	12.3	8	28	7	25	2	13	
5/15/81	2330	10717.0	1.3	12.3	8	29	7	26	2	14	
5/15/81	2345	10717.0	1.4	12.2	8	30	7	27	2	14	
5/15/81	2400	10717.0	1.4	12.2	8	29	7	26	2	14	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/16/81	15	10717.0	1.2	12.3	8	28	7	25	2	13	
5/16/81	30	10717.0	1.2	12.3	8	28	7	25	2	13	
5/16/81	45	10717.0	1.0	12.4	10	20	8	17	2	9	
5/16/81	100	10717.0	1.4	12.1	7	29	6	26	2	14	
5/16/81	115	10717.0	1.3	12.2	8	29	7	26	2	14	
5/16/81	130	10717.0	1.3	12.2	9	28	8	25	2	13	
5/16/81	145	10717.0	1.2	12.3	10	28	9	25	2	13	
5/16/81	200	10717.0	1.2	12.3	9	28	8	25	2	13	
5/16/81	215	10717.0	1.0	12.4	10	26	8	23	2	12	
5/16/81	230	10717.0	1.0	12.4	10	26	8	23	2	12	
5/16/81	245	10717.0	1.3	12.2	9	29	8	26	2	14	
5/16/81	300	10717.0	1.4	12.1	9	30	8	27	2	14	
5/16/81	315	10717.0	1.3	12.2	11	28	10	25	3	13	
5/16/81	330	10717.0	1.2	12.2	10	27	9	24	2	13	
5/16/81	345	10717.0	1.1	12.3	11	26	9	23	3	12	
5/16/81	400	10717.0	1.4	12.1	11	28	10	25	3	13	
5/16/81	415	10717.0	1.3	12.2	11	27	10	24	3	13	
5/16/81	430	10717.0	1.4	12.1	10	28	9	25	3	13	
5/16/81	445	10717.0	1.5	12.1	11	29	10	26	3	14	
5/16/81	500	10717.0	1.4	12.1	11	30	10	27	3	14	
5/16/81	515	10717.0	1.5	12.1	12	30	11	27	3	15	
5/16/81	530	10717.0	1.5	12.0	11	30	10	27	3	15	
5/16/81	545	10717.0	1.6	12.0	11	31	10	28	3	15	
5/16/81	600	10717.0	1.4	12.1	11	29	10	26	3	14	
5/16/81	615	10717.0	1.4	12.1	13	29	11	26	3	14	
5/16/81	630	10717.0	1.5	12.0	12	30	11	27	3	15	
5/16/81	645	10717.0	1.3	12.2	12	28	10	25	3	13	
5/16/81	700	10717.0	1.7	11.4	56	46	52	42	17	23	
5/16/81	715	10717.0	1.3	12.3	9	28	8	25	2	13	
5/16/81	730	10717.0	1.2	12.3	10	28	9	25	2	13	
5/16/81	745	10717.0	1.2	12.3	10	28	9	25	2	13	
5/16/81	800	10717.0	1.2	12.3	9	29	8	26	2	14	
5/16/81	815	10717.0	1.2	12.3	9	29	8	26	2	14	
5/16/81	830	10717.0	1.1	12.3	11	28	9	25	3	13	
5/16/81	845	10717.0	1.0	12.4	12	28	10	25	3	13	
5/16/81	900	10717.0	.9	12.5	91	27	81	24	26	13	
5/16/81	915	10717.0	.2	9.7	1502	8	1298	6	427	3	
5/16/81	930	10717.0	.2	6.4	1502	4	1298	3	427	1	
5/16/81	945	10717.0	.4	7.6	1384	16	1208	13	397	7	
5/16/81	1000	10717.0	5.7	9.5	-1	71	-1	83	0	45	
5/16/81	1015	10717.0	5.7	9.4	11	72	12	84	4	45	
5/16/81	1030	10717.0	5.8	9.5	10	71	11	84	3	45	
5/16/81	1045	10717.0	5.7	9.5	8	72	9	84	3	45	
5/16/81	1100	10717.0	5.6	9.6	8	72	9	84	3	45	
5/16/81	1115	10717.0	5.6	9.6	6	73	7	85	2	46	
5/16/81	1130	10717.0	5.6	9.6	6	73	7	85	2	46	
5/16/81	1145	10717.0	5.7	9.6	5	74	5	87	1	47	
5/16/81	1200	10717.0	5.7	9.6	3	74	3	87	1	47	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/16/81	1215	10717.0	5.7	9.6	5	75	5	88	1	47	
5/16/81	1230	10717.0	5.7	9.6	5	75	5	88	1	47	
5/16/81	1245	10717.0	5.7	9.6	7	76	8	89	2	48	
5/16/81	1300	10717.0	5.5	9.7	9	75	10	87	3	47	
5/16/81	1315	10717.0	5.6	10.0	9	75	10	87	3	47	
5/16/81	1330	10717.0	.0	.0	0	0	0	0	0	0	K
5/16/81	1345	10717.0	5.7	9.6	9	76	10	89	3	48	
5/16/81	1400	10717.0	5.7	9.6	9	76	10	89	3	48	
5/16/81	1415	10717.0	5.6	9.7	8	76	9	88	3	48	
5/16/81	1430	10717.0	5.8	9.6	7	76	8	90	2	48	
5/16/81	1445	10717.0	5.6	9.6	5	76	5	88	1	48	
5/16/81	1500	10717.0	5.6	9.6	7	76	8	88	2	48	
5/16/81	1515	10717.0	5.7	9.6	7	77	8	90	2	49	
5/16/81	1530	10717.0	5.6	9.6	9	77	10	90	3	48	
5/16/81	1545	10717.0	5.6	9.6	7	77	8	90	2	48	
5/16/81	1600	10717.0	5.7	9.6	8	78	9	91	3	49	
5/16/81	1615	10717.0	5.7	9.6	8	78	9	91	3	49	
5/16/81	1630	10717.0	5.5	9.7	8	76	9	88	3	47	
5/16/81	1645	10717.0	5.7	9.6	9	77	10	90	3	49	
5/16/81	1700	10717.0	5.7	9.6	9	77	10	90	3	49	
5/16/81	1715	10717.0	5.6	9.7	9	76	10	88	3	48	
5/16/81	1730	10717.0	5.7	9.6	7	77	8	90	2	49	
5/16/81	1745	10717.0	5.7	9.6	7	76	8	89	2	48	
5/16/81	1800	10717.0	5.6	9.6	8	76	9	88	3	48	
5/16/81	1815	10717.0	5.7	9.6	8	77	9	90	3	49	
5/16/81	1830	10717.0	5.5	9.7	8	77	9	89	3	48	
5/16/81	1845	10717.0	5.5	9.7	8	77	9	89	3	48	
5/16/81	1900	10717.0	5.6	9.7	8	77	9	90	3	48	
5/16/81	1915	10717.0	5.6	9.7	7	77	8	90	2	48	
5/16/81	1930	10717.0	5.6	9.7	9	76	10	88	3	48	
5/16/81	1945	10717.0	5.6	9.7	10	76	11	88	3	48	
5/16/81	2000	10717.0	5.7	9.6	9	77	10	90	3	49	
5/16/81	2015	10717.0	5.7	9.6	9	76	10	89	3	48	
5/16/81	2030	10717.0	5.7	9.6	9	76	10	89	3	48	
5/16/81	2045	10717.0	5.8	9.5	9	76	10	90	3	48	
5/16/81	2100	10717.0	5.8	9.6	9	76	10	90	3	48	
5/16/81	2115	10717.0	5.8	9.5	9	77	10	91	3	49	
5/16/81	2130	10717.0	5.8	9.6	9	77	10	91	3	49	
5/16/81	2145	10717.0	5.8	9.5	9	77	10	91	3	49	
5/16/81	2200	10717.0	5.8	9.5	10	76	11	90	3	48	
5/16/81	2215	10717.0	5.8	9.6	10	76	11	90	3	48	
5/16/81	2230	10717.0	6.0	9.4	9	76	10	91	3	49	
5/16/81	2245	10717.0	5.9	9.5	10	75	11	89	3	48	
5/16/81	2300	10717.0	5.9	9.5	10	74	11	88	3	47	
5/16/81	2315	10717.0	6.1	9.4	10	74	12	89	3	48	
5/16/81	2330	10717.0	6.1	9.4	10	74	12	89	3	48	
5/16/81	2345	10717.0	6.0	9.5	10	73	12	87	3	47	
5/16/81	2400	10717.0	6.1	9.4	10	74	12	89	3	48	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/17/81	15	10717.0	6.1	9.4	9	74	10	89	3	48	
5/17/81	30	10717.0	6.0	9.4	10	74	12	88	3	48	
5/17/81	45	10717.0	6.1	9.4	10	75	12	90	3	49	
5/17/81	100	10717.0	6.1	9.4	10	75	12	90	3	49	
5/17/81	115	10717.0	6.1	9.4	10	75	12	90	3	49	
5/17/81	130	10717.0	6.1	9.4	9	75	10	90	3	49	
5/17/81	145	10717.0	6.1	9.4	9	74	10	89	3	48	
5/17/81	200	10717.0	6.1	9.4	10	73	12	88	3	47	
5/17/81	215	10717.0	6.0	9.4	10	73	12	87	3	47	
5/17/81	230	10717.0	6.0	9.5	10	73	12	87	3	47	
5/17/81	245	10717.0	6.1	9.4	10	73	12	88	3	47	
5/17/81	300	10717.0	6.1	9.4	10	73	12	88	3	47	
5/17/81	315	10717.0	6.0	9.4	9	74	10	88	3	48	
5/17/81	330	10717.0	6.0	9.4	10	74	12	88	3	48	
5/17/81	345	10717.0	6.0	9.5	10	74	12	88	3	48	
5/17/81	400	10717.0	6.0	9.5	10	75	12	90	3	48	
5/17/81	415	10717.0	6.0	9.4	10	75	12	90	3	48	
5/17/81	430	10717.0	6.1	9.4	9	74	10	89	3	48	
5/17/81	445	10717.0	6.1	9.4	9	74	10	89	3	48	
5/17/81	500	10717.0	6.0	9.4	10	73	12	87	3	47	
5/17/81	515	10717.0	6.1	9.4	10	72	12	87	3	47	
5/17/81	530	10717.0	6.0	9.4	11	72	13	86	4	46	
5/17/81	545	10717.0	6.0	9.4	10	72	12	86	3	46	
5/17/81	600	10717.0	6.0	9.4	10	72	12	86	3	46	
5/17/81	615	10717.0	5.9	9.5	10	73	11	87	3	47	
5/17/81	630	10717.0	6.1	9.4	9	72	10	87	3	47	
5/17/81	645	10717.0	5.8	9.5	11	72	13	85	4	46	
5/17/81	700	10717.0	2.9	9.8	200	95	198	94	65	51	
5/17/81	715	10717.0	7.0	8.7	5	73	6	94	2	50	
5/17/81	730	10717.0	7.3	8.6	4	74	5	97	1	52	
5/17/81	745	10717.0	7.3	8.6	4	76	5	100	1	54	
5/17/81	800	10717.0	7.3	8.7	4	76	5	100	1	54	
5/17/81	815	10717.0	7.1	8.8	4	76	5	98	1	53	
5/17/81	830	10717.0	7.2	8.8	4	77	5	100	1	54	
5/17/81	845	10717.0	7.3	8.7	3	78	3	102	1	55	
5/17/81	900	10717.0	7.2	8.7	4	79	5	103	1	55	
5/17/81	915	10717.0	7.3	8.7	3	79	3	103	1	56	
5/17/81	930	10717.0	7.3	8.7	4	80	5	105	1	57	
5/17/81	945	10717.0	7.2	8.7	3	81	3	105	1	57	
5/17/81	1000	10717.0	7.3	8.7	4	82	5	107	1	58	
5/17/81	1015	10717.0	7.3	8.7	3	83	3	109	1	59	
5/17/81	1030	10717.0	7.3	8.7	3	83	3	109	1	59	
5/17/81	1045	10717.0	7.2	8.7	3	82	3	107	1	58	
5/17/81	1100	10717.0	7.2	8.7	3	82	3	107	1	58	
5/17/81	1115	10717.0	7.3	8.7	3	82	3	107	1	58	
5/17/81	1130	10717.0	7.3	8.7	3	83	3	109	1	59	
5/17/81	1145	10717.0	7.3	8.7	3	83	3	109	1	59	
5/17/81	1200	10717.0	7.3	8.7	2	83	2	109	0	59	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/17/81	1215	10717.0	7.4	8.7	2	83	2	110	0	59	
5/17/81	1230	10717.0	7.3	8.7	2	83	2	109	0	59	
5/17/81	1245	10717.0	7.3	8.7	1	82	1	107	0	58	
5/17/81	1300	10717.0	7.3	8.7	1	83	1	109	0	59	
5/17/81	1315	10717.0	7.3	8.7	0	83	0	109	0	59	
5/17/81	1330	10717.0	7.2	8.8	1	83	1	108	0	58	
5/17/81	1345	10717.0	7.2	8.7	2	82	2	107	0	58	
5/17/81	1400	10717.0	7.2	8.7	2	82	2	107	0	58	
5/17/81	1415	10717.0	7.2	8.8	2	81	2	105	0	57	
5/17/81	1430	10717.0	7.2	8.7	4	81	5	105	1	57	
5/17/81	1445	10717.0	7.1	8.8	4	82	5	106	1	57	
5/17/81	1500	10717.0	7.2	8.7	4	82	5	107	1	58	
5/17/81	1515	10717.0	7.1	8.8	4	82	5	106	1	57	
5/17/81	1530	10717.0	7.1	8.8	4	82	5	106	1	57	
5/17/81	1545	10717.0	7.1	8.8	4	82	5	106	1	57	
5/17/81	1600	10717.0	7.1	8.8	4	83	5	107	1	58	
5/17/81	1615	10717.0	7.1	8.8	4	83	5	107	1	58	
5/17/81	1630	10717.0	7.1	8.8	4	83	5	107	1	58	
5/17/81	1645	10717.0	6.9	8.8	5	83	6	106	2	57	
5/17/81	1700	10717.0	7.1	8.8	5	83	6	107	2	58	
5/17/81	1715	10717.0	7.1	8.8	5	82	6	106	2	57	
5/17/81	1730	10717.0	7.1	8.8	5	82	6	106	2	57	
5/17/81	1745	10717.0	6.9	8.9	5	82	6	104	2	56	
5/17/81	1800	10717.0	7.0	8.9	5	81	6	104	2	56	
5/17/81	1815	10717.0	7.0	8.8	5	82	6	105	2	57	
5/17/81	1830	10717.0	7.0	8.8	5	82	6	105	2	57	
5/17/81	1845	10717.0	7.0	8.8	4	82	5	105	1	57	
5/17/81	1900	10717.0	7.1	8.8	4	83	5	107	1	58	
5/17/81	1915	10717.0	7.1	8.8	4	83	5	107	1	58	
5/17/81	1930	10717.0	7.0	8.8	4	83	5	106	1	57	
5/17/81	1945	10717.0	7.0	8.8	4	83	5	106	1	57	
5/17/81	2000	10717.0	7.0	8.8	5	83	6	106	2	57	
5/17/81	2015	10717.0	7.0	8.9	5	83	6	106	2	57	
5/17/81	2030	10717.0	7.0	8.8	4	83	5	106	1	57	
5/17/81	2045	10717.0	7.0	8.8	4	82	5	105	1	57	
5/17/81	2100	10717.0	7.2	8.7	4	82	5	107	1	58	
5/17/81	2115	10717.0	7.2	8.7	4	81	5	105	1	57	
5/17/81	2130	10717.0	7.1	8.8	4	82	5	106	1	57	
5/17/81	2145	10717.0	7.1	8.7	4	82	5	106	1	57	
5/17/81	2200	10717.0	7.2	8.7	5	83	6	108	2	58	
5/17/81	2215	10717.0	7.2	8.7	5	82	6	107	2	58	
5/17/81	2230	10717.0	7.2	8.7	5	82	6	107	2	58	
5/17/81	2245	10717.0	7.2	8.7	4	83	5	108	1	58	
5/17/81	2300	10717.0	7.2	8.7	4	82	5	107	1	58	
5/17/81	2315	10717.0	7.2	8.7	4	82	5	107	1	58	
5/17/81	2330	10717.0	7.2	8.7	5	80	6	104	2	56	
5/17/81	2345	10717.0	7.3	8.7	4	79	5	103	1	56	
5/17/81	2400	10717.0	7.3	8.6	4	78	5	102	1	55	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/18/81	15	10717.0	7.1	8.7	4	77	5	99	1	54	
5/18/81	30	10717.0	7.2	8.7	5	76	6	99	2	53	
5/18/81	45	10717.0	7.1	8.7	4	77	5	99	1	54	
5/18/81	100	10717.0	7.2	8.7	4	76	5	99	1	53	
5/18/81	115	10717.0	7.1	8.7	3	77	3	99	1	54	
5/18/81	130	10717.0	7.1	8.7	3	77	3	99	1	54	
5/18/81	145	10717.0	7.2	8.7	3	77	3	100	1	54	
5/18/81	200	10717.0	7.2	8.7	3	77	3	100	1	54	
5/18/81	215	10717.0	7.3	8.6	3	77	3	101	1	54	
5/18/81	230	10717.0	7.4	8.6	4	76	5	100	1	54	
5/18/81	245	10717.0	7.4	8.5	3	75	3	99	1	53	
5/18/81	300	10717.0	7.4	8.5	3	75	3	99	1	53	
5/18/81	315	10717.0	7.3	8.6	3	75	3	98	1	53	
5/18/81	330	10717.0	7.2	8.6	3	74	3	96	1	52	
5/18/81	345	10717.0	7.3	8.6	3	75	3	98	1	53	
5/18/81	400	10717.0	7.2	8.6	3	75	3	97	1	53	
5/18/81	415	10717.0	7.2	8.6	3	76	3	99	1	53	
5/18/81	430	10717.0	7.4	8.5	4	76	5	100	1	54	
5/18/81	445	10717.0	7.4	8.5	3	76	3	100	1	54	
5/18/81	500	10717.0	7.3	8.6	3	76	3	100	1	54	
5/18/81	515	10717.0	7.3	8.6	3	76	3	100	1	54	
5/18/81	530	10717.0	7.4	8.6	3	75	3	99	1	53	
5/18/81	545	10717.0	7.3	8.5	2	74	2	97	0	52	
5/18/81	600	10717.0	7.5	8.4	3	75	4	100	1	54	
5/18/81	615	10717.0	7.3	8.5	3	74	3	97	1	52	
5/18/81	630	10717.0	7.2	8.6	3	74	3	96	1	52	
5/18/81	645	10717.0	7.3	8.6	3	74	3	97	1	52	
5/18/81	700	10717.0	.0	.0	0	0	0	0	0	0	C
5/18/81	715	10717.0	6.7	8.3	21	77	26	97	8	52	
5/18/81	730	10717.0	7.2	8.5	8	74	10	96	3	52	
5/18/81	745	10717.0	2.6	10.7	546	38	534	37	175	20	
5/18/81	800	10717.0	4.6	9.9	3	64	3	70	1	38	
5/18/81	815	10717.0	4.1	10.5	12	60	12	63	4	34	
5/18/81	830	10717.0	3.8	10.7	8	57	8	59	2	32	
5/18/81	845	10717.0	3.5	10.9	6	56	6	57	2	31	
5/18/81	900	10717.0	3.5	10.9	6	56	6	57	2	31	
5/18/81	915	10717.0	3.8	10.7	6	56	6	58	2	31	
5/18/81	930	10717.0	3.6	10.8	7	56	7	57	2	31	
5/18/81	945	10717.0	3.1	11.2	7	54	7	54	2	29	
5/18/81	1000	10717.0	2.6	11.5	8	56	7	54	2	29	
5/18/81	1015	10717.0	1.9	11.9	8	54	7	50	2	27	
5/18/81	1030	10717.0	1.4	12.2	8	50	7	45	2	24	
5/18/81	1045	10717.0	1.0	12.4	15	43	13	38	4	20	
5/18/81	1100	10717.0	1.0	12.4	9	43	8	38	2	20	
5/18/81	1115	10717.0	1.0	12.4	8	42	7	37	2	20	
5/18/81	1130	10717.0	.9	12.5	9	41	8	36	2	19	
5/18/81	1145	10717.0	.9	12.5	10	40	8	35	2	19	
5/18/81	1200	10717.0	.9	12.5	10	41	8	36	2	19	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/18/81	1215	10717.0	1.2	12.2	15	41	13	37	4	20	
5/18/81	1230	10717.0	2.0	11.8	292	39	276	36	91	20	
5/18/81	1245	10717.0	2.6	11.4	24	48	23	46	7	25	
5/18/81	1300	10717.0	2.5	11.5	15	47	14	45	4	24	
5/18/81	1315	10717.0	2.3	11.6	8	45	7	43	2	23	
5/18/81	1330	10717.0	2.2	11.6	8	45	7	43	2	23	
5/18/81	1345	10717.0	2.3	11.6	8	45	7	43	2	23	
5/18/81	1400	10717.0	2.3	11.6	8	45	7	43	2	23	
5/18/81	1415	10717.0	2.2	11.7	8	44	7	42	2	22	
5/18/81	1430	10717.0	2.0	11.8	9	42	8	39	2	21	
5/18/81	1445	10717.0	1.5	12.1	31	35	28	32	9	17	
5/18/81	1500	10717.0	2.0	11.9	48	50	45	47	14	25	
5/18/81	1515	10717.0	1.8	12.1	8	39	7	36	2	19	
5/18/81	1530	10717.0	1.9	12.0	9	41	8	38	2	20	
5/18/81	1545	10717.0	1.8	12.0	8	40	7	37	2	20	
5/18/81	1600	10717.0	1.5	12.2	162	35	149	32	49	17	
5/18/81	1615	10717.0	1.9	12.0	8	40	7	37	2	20	
5/18/81	1630	10717.0	1.7	12.1	8	38	7	35	2	19	
5/18/81	1645	10717.0	1.8	12.0	9	39	8	36	2	19	
5/18/81	1700	10717.0	1.3	12.3	30	33	27	30	9	16	
5/18/81	1715	10717.0	1.6	12.1	53	35	49	32	16	17	
5/18/81	1730	10717.0	.6	12.7	5	23	4	20	1	11	
5/18/81	1745	10717.0	1.3	12.3	5	32	4	29	1	15	
5/18/81	1800	10717.0	1.1	12.4	30	28	27	25	8	13	
5/18/81	1815	10717.0	.8	12.7	261	25	232	22	76	12	
5/18/81	1830	10717.0	.7	12.7	77	24	68	21	22	11	
5/18/81	1845	10717.0	.8	12.6	5	26	4	23	1	12	
5/18/81	1900	10717.0	.5	12.8	279	21	244	18	80	9	
5/18/81	1915	10717.0	.5	12.8	30	22	26	19	8	10	
5/18/81	1930	10717.0	.3	12.9	597	19	518	16	170	8	
5/18/81	1945	10717.0	.4	13.1	5	20	4	17	1	9	
5/18/81	2000	10717.0	.3	13.1	1501	15	1304	13	429	7	
5/18/81	2015	10717.0	.3	13.1	1501	14	1304	12	429	6	
5/18/81	2030	10717.0	.2	13.2	1502	10	1298	8	427	4	
5/18/81	2045	10717.0	.2	13.2	1502	6	1298	5	427	2	
5/18/81	2100	10717.0	.3	13.1	1502	5	1305	4	429	2	
5/18/81	2115	10717.0	.3	13.1	1502	5	1305	4	429	2	
5/18/81	2130	10717.0	.3	13.1	1502	5	1305	4	429	2	
5/18/81	2145	10717.0	.3	13.1	1503	6	1306	5	429	2	
5/18/81	2200	10717.0	.3	13.1	1503	6	1306	5	429	2	
5/18/81	2215	10717.0	.3	13.1	1503	7	1306	6	429	3	
5/18/81	2230	10717.0	2.5	9.9	798	27	776	26	255	14	
5/18/81	2245	10717.0	2.6	10.2	5	28	4	27	1	14	
5/18/81	2300	10717.0	1.0	9.5	1255	10	1128	8	371	4	
5/18/81	2315	10717.0	10.8	6.4	84	64	148	113	48	61	
5/18/81	2330	10717.0	6.6	9.1	28	72	35	90	11	48	
5/18/81	2345	10717.0	5.9	9.5	16	70	19	83	6	45	
5/18/81	2400	10717.0	4.6	10.2	10	65	10	71	3	38	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/19/81	15	10717.0	4.6	10.3	12	69	13	75	4	41	
5/19/81	30	10717.0	4.6	10.3	12	69	13	75	4	41	
5/19/81	45	10717.0	5.5	9.8	9	68	10	79	3	42	
5/19/81	100	10717.0	5.4	9.7	8	70	9	80	3	43	
5/19/81	115	10717.0	5.4	9.8	9	69	10	79	3	43	
5/19/81	130	10717.0	5.4	9.7	8	71	9	81	3	44	
5/19/81	145	10717.0	5.4	9.8	9	71	10	81	3	44	
5/19/81	200	10717.0	5.5	9.7	9	71	10	82	3	44	
5/19/81	215	10717.0	5.5	9.7	9	71	10	82	3	44	
5/19/81	230	10717.0	5.5	9.7	8	71	9	82	3	44	
5/19/81	245	10717.0	5.6	9.6	9	71	10	83	3	45	
5/19/81	300	10717.0	5.5	9.7	9	71	10	82	3	44	
5/19/81	315	10717.0	5.4	9.7	8	70	9	80	3	43	
5/19/81	330	10717.0	5.3	9.8	8	69	9	79	3	42	
5/19/81	345	10717.0	5.5	9.7	8	70	9	81	3	44	
5/19/81	400	10717.0	5.5	9.7	8	70	9	81	3	44	
5/19/81	415	10717.0	5.5	9.7	9	70	10	81	3	44	
5/19/81	430	10717.0	5.5	9.7	8	70	9	81	3	44	
5/19/81	445	10717.0	5.5	9.7	8	70	9	81	3	44	
5/19/81	500	10717.0	5.5	9.7	9	71	10	82	3	44	
5/19/81	[illegible]	10717.0	5.5	9.7	10	72	11	83	3	45	
5/19/81	[illegible]	10717.0	5.5	9.7	10	72	11	83	3	45	
5/19/81	[illegible]	10717.0	5.5	9.7	9	72	10	83	3	45	
5/19/81	[illegible]	[illegible]	5.4	9.7	9	72	10	83	3	45	
5/19/81	[illegible]	[illegible]	5.4	9.7	9	72	10	83	3	45	
5/19/81	[illegible]	[illegible]	5.4	9.7	9	72	10	83	3	45	
5/19/81	[illegible]	[illegible]	5.5	9.7	10	71	11	82	3	44	
5/19/81	700	[illegible]	.0	.0	0	0	0	0	0	0	C
5/19/81	715	[illegible]	3.3	10.1	33	52	33	52	11	28	
5/19/81	730	10717.0	3.1	11.1	10	48	10	48	3	26	
5/19/81	745	10717.0	2.0	11.8	10	37	9	35	3	19	
5/19/81	800	10717.0	2.1	11.7	10	37	9	35	3	19	
5/19/81	815	10717.0	1.7	11.9	10	35	9	32	3	17	
5/19/81	830	10717.0	1.8	11.8	10	36	9	33	3	18	
5/19/81	845	10717.0	1.8	11.9	11	36	10	33	3	18	
5/19/81	900	10717.0	1.8	11.9	11	35	10	32	3	17	
5/19/81	915	10717.0	1.5	11.8	10	33	9	30	3	16	
5/19/81	930	10717.0	1.2	11.9	3	30	2	27	0	14	
5/19/81	945	10717.0	1.0	11.8	706	24	635	21	209	11	
5/19/81	1000	10717.0	2.4	9.7	730	39	706	37	232	20	
5/19/81	1015	10717.0	3.8	10.3	22	57	23	59	7	32	
5/19/81	1030	10717.0	3.3	10.6	14	53	14	53	4	29	
5/19/81	1045	10717.0	4.2	10.4	10	56	10	60	3	32	
5/19/81	1100	10717.0	3.6	10.4	9	54	9	55	3	30	
5/19/81	1115	10717.0	3.7	10.3	9	54	9	56	3	30	
5/19/81	1130	10717.0	3.0	10.8	10	48	10	48	3	26	
5/19/81	1145	10717.0	2.7	11.0	9	45	8	44	2	24	
5/19/81	1200	10717.0	2.4	11.2	10	42	9	40	3	22	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/19/81	1215	10717.0	2.0	11.4	10	38	9	35	3	19	
5/19/81	1230	10717.0	1.8	11.5	10	36	9	33	3	18	
5/19/81	1245	10717.0	1.5	11.6	11	33	10	30	3	16	
5/19/81	1300	10717.0	.6	12.9	400	24	352	21	116	11	
5/19/81	1315	10717.0	1.7	11.2	2	36	1	33	0	18	
5/19/81	1330	10717.0	3.0	10.7	10	50	10	50	3	27	
5/19/81	1345	10717.0	2.2	11.3	10	40	9	38	3	20	
5/19/81	1400	10717.0	2.2	11.3	9	40	8	38	2	20	
5/19/81	1415	10717.0	2.2	11.3	9	39	8	37	2	20	
5/19/81	1430	10717.0	.0	11.3	0	39	0	33	0	18	C
5/19/81	1445	10717.0	.0	11.3	0	39	0	33	0	18	C
5/19/81	1500	10717.0	2.4	11.3	42	59	40	57	13	30	
5/19/81	1515	10717.0	2.3	11.3	9	41	8	39	2	21	
5/19/81	1530	10717.0	2.1	11.3	10	39	9	37	3	20	
5/19/81	1545	10717.0	2.1	11.3	10	40	9	38	3	20	
5/19/81	1600	10717.0	2.1	11.3	10	39	9	37	3	20	
5/19/81	1615	10717.0	2.0	11.3	10	39	9	36	3	20	
5/19/81	1630	10717.0	1.7	11.5	10	38	9	35	3	19	
5/19/81	1645	10717.0	2.1	11.3	11	39	10	37	3	20	
5/19/81	1700	10717.0	2.1	11.3	10	39	9	37	3	20	
5/19/81	1715	10717.0	2.0	11.3	11	38	10	35	3	19	
5/19/81	1730	10717.0	1.8	11.4	10	36	9	33	3	18	
5/19/81	1745	10717.0	1.9	11.4	10	37	9	34	3	18	
5/19/81	1800	10717.0	1.9	11.4	10	37	9	34	3	18	
5/19/81	1815	10717.0	1.6	11.6	10	34	9	31	3	17	
5/19/81	1830	10717.0	1.7	11.5	11	35	10	32	3	17	
5/19/81	1845	10717.0	1.7	11.5	36	35	33	32	11	17	
5/19/81	1900	10717.0	.2	13.2	1502	10	1298	8	427	4	
5/19/81	1915	10717.0	.2	13.2	1450	16	1253	13	412	7	
5/19/81	1930	10717.0	.6	12.9	1120	18	987	15	325	8	
5/19/81	1945	10717.0	.6	12.9	1190	20	1049	17	345	9	
5/19/81	2000	10717.0	2.1	10.3	830	33	790	31	260	17	
5/19/81	2015	10717.0	3.2	10.6	26	47	26	47	8	25	
5/19/81	2030	10717.0	3.1	10.6	16	47	16	47	5	25	
5/19/81	2045	10717.0	3.5	10.4	12	50	12	51	4	27	
5/19/81	2100	10717.0	3.8	10.2	9	52	9	54	3	29	
5/19/81	2115	10717.0	3.2	10.6	10	48	10	48	3	26	
5/19/81	2130	10717.0	3.4	10.4	9	49	9	50	3	27	
5/19/81	2145	10717.0	3.2	10.5	9	49	9	49	2	26	
5/19/81	2200	10717.0	3.4	10.4	10	50	10	51	3	27	
5/19/81	2215	10717.0	3.3	10.4	10	49	10	49	3	27	
5/19/81	2230	10717.0	3.6	10.3	10	52	10	53	3	29	
5/19/81	2245	10717.0	3.5	10.3	10	53	10	54	3	29	
5/19/81	2300	10717.0	3.5	10.4	10	51	10	52	3	28	
5/19/81	2315	10717.0	3.4	10.4	10	51	10	52	3	28	
5/19/81	2330	10717.0	3.3	10.5	9	50	9	50	3	27	
5/19/81	2345	10717.0	3.5	10.4	11	51	11	52	3	28	
5/19/81	2400	10717.0	2.2	11.2	13	38	12	36	4	19	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/20/81	15	10717.0	1.4	11.6	12	29	11	26	3	14	
5/20/81	30	10717.0	1.3	11.6	12	28	10	25	3	13	
5/20/81	45	10717.0	1.5	11.6	11	30	10	27	3	15	
5/20/81	100	10717.0	1.4	11.6	11	30	10	27	3	14	
5/20/81	115	10717.0	1.3	11.6	11	29	10	26	3	14	
5/20/81	130	10717.0	1.3	11.6	11	29	10	26	3	14	
5/20/81	145	10717.0	1.3	11.7	11	29	10	26	3	14	
5/20/81	200	10717.0	1.4	11.6	11	30	10	27	3	14	
5/20/81	215	10717.0	1.4	11.6	10	30	9	27	3	14	
5/20/81	230	10717.0	1.4	11.7	11	30	10	27	3	14	
5/20/81	245	10717.0	1.3	11.6	11	29	10	26	3	14	
5/20/81	300	10717.0	1.5	11.6	11	30	10	27	3	15	
5/20/81	315	10717.0	1.5	11.6	11	31	10	28	3	15	
5/20/81	330	10717.0	1.3	11.7	10	29	9	26	3	14	
5/20/81	345	10717.0	1.3	11.6	300	29	273	26	90	14	
5/20/81	400	10717.0	1.5	11.6	41	31	37	28	12	15	
5/20/81	415	10717.0	1.4	11.6	21	29	19	26	6	14	
5/20/81	430	10717.0	1.8	11.4	11	32	10	29	3	16	
5/20/81	445	10717.0	1.6	11.5	10	31	9	28	3	15	
5/20/81	500	10717.0	1.8	11.4	10	32	9	29	3	16	
5/20/81	515	10717.0	1.8	11.4	11	32	10	29	3	16	
5/20/81	530	10717.0	1.2	11.6	12	28	10	25	3	13	
5/20/81	545	10717.0	1.7	11.5	15	32	13	29	4	16	
5/20/81	600	10717.0	1.7	11.5	15	32	13	29	4	16	
5/20/81	615	10717.0	1.8	11.5	8	33	7	30	2	16	
5/20/81	630	10717.0	1.8	11.4	8	33	7	30	2	16	
5/20/81	645	10717.0	1.8	11.5	8	33	7	30	2	16	
5/20/81	700	10717.0	1.4	11.7	7	30	6	27	2	14	
5/20/81	715	10717.0	1.3	11.7	3	29	2	26	0	14	
5/20/81	730	10717.0	1.8	12.0	10	32	9	29	3	16	
5/20/81	745	10717.0	1.8	12.0	10	32	9	29	3	16	
5/20/81	800	10717.0	1.9	10.5	48	34	45	32	14	17	
5/20/81	815	10717.0	1.8	12.0	10	33	9	30	3	16	
5/20/81	830	10717.0	1.6	12.1	10	36	9	33	3	18	
5/20/81	845	10717.0	1.8	12.1	10	33	9	30	3	16	
5/20/81	900	10717.0	1.5	12.2	0	31	0	28	0	15	
5/20/81	915	10717.0	1.7	11.9	0	33	0	30	0	16	
5/20/81	930	10717.0	1.6	12.1	10	32	9	29	3	16	
5/20/81	945	10717.0	2.0	11.9	13	34	12	32	4	17	
5/20/81	1000	10717.0	1.7	12.1	15	32	13	29	4	16	
5/20/81	1015	10717.0	1.8	12.0	14	33	13	30	4	16	
5/20/81	1030	10717.0	1.5	12.2	20	30	18	27	6	15	
5/20/81	1045	10717.0	1.7	12.1	13	33	12	30	3	16	
5/20/81	1100	10717.0	1.7	12.1	13	33	12	30	3	16	
5/20/81	1115	10717.0	1.7	12.1	14	33	13	30	4	16	
5/20/81	1130	10717.0	1.8	12.0	12	34	11	31	3	17	
5/20/81	1145	10717.0	1.8	12.1	11	34	10	31	3	17	
5/20/81	1200	10717.0	1.8	12.1	11	35	10	32	3	17	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/20/81	1215	10717.0	1.8	12.1	13	34	12	31	4	17	
5/20/81	1230	10717.0	1.7	12.1	13	33	12	30	3	16	
5/20/81	1245	10717.0	1.8	12.1	13	33	12	30	4	16	
5/20/81	1300	10717.0	1.8	12.1	12	33	11	30	3	16	
5/20/81	1315	10717.0	1.8	12.1	11	33	10	30	3	16	
5/20/81	1330	10717.0	1.8	12.1	11	34	10	31	3	17	
5/20/81	1345	10717.0	1.7	12.1	11	33	10	30	3	16	
5/20/81	1400	10717.0	1.8	12.0	12	34	11	31	3	17	
5/20/81	1415	10717.0	1.7	12.1	12	33	11	30	3	16	
5/20/81	1430	10717.0	1.6	12.2	13	33	12	30	3	16	
5/20/81	1445	10717.0	1.6	12.1	13	33	12	30	3	16	
5/20/81	1500	10717.0	1.8	12.1	13	34	12	31	4	17	
5/20/81	1515	10717.0	1.7	12.2	13	34	12	31	3	17	
5/20/81	1530	10717.0	1.8	12.1	13	35	12	32	4	17	
5/20/81	1545	10717.0	1.7	12.1	13	34	12	31	3	17	
5/20/81	1600	10717.0	1.7	12.1	12	34	11	31	3	17	
5/20/81	1615	10717.0	1.5	12.2	12	32	11	29	3	16	
5/20/81	1630	10717.0	1.6	12.2	12	33	11	30	3	16	
5/20/81	1645	10717.0	1.5	12.2	12	32	11	29	3	16	
5/20/81	1700	10717.0	.0	.0	0	0	0	0	0	0	C
5/20/81	1715	10717.0	.0	.0	0	0	0	0	0	0	C
5/20/81	1730	10717.0	.0	.0	0	0	0	0	0	0	C
5/20/81	1745	10717.0	.0	.0	0	0	0	0	0	0	C
5/20/81	1800	10717.0	1.5	12.2	12	61	11	56	3	30	
5/20/81	1815	10717.0	1.4	12.3	12	30	11	27	3	14	
5/20/81	1830	10717.0	1.5	12.2	11	31	10	28	3	15	
5/20/81	1845	10717.0	1.6	12.2	11	31	10	28	3	15	
5/20/81	1900	10717.0	1.6	12.2	11	31	10	28	3	15	
5/20/81	1915	10717.0	1.5	12.2	11	31	10	28	3	15	
5/20/81	1930	10717.0	1.6	12.2	12	31	11	28	3	15	
5/20/81	1945	10717.0	1.6	12.1	12	31	11	28	3	15	
5/20/81	2000	10717.0	1.6	12.1	11	31	10	28	3	15	
5/20/81	2015	10717.0	1.7	12.1	11	31	10	28	3	15	
5/20/81	2030	10717.0	1.7	12.1	12	31	11	28	3	15	
5/20/81	2045	10717.0	1.8	12.1	13	32	12	29	4	16	
5/20/81	2100	10717.0	1.7	12.1	13	31	12	28	3	15	
5/20/81	2115	10717.0	1.7	12.1	12	31	11	28	3	15	
5/20/81	2130	10717.0	1.8	12.1	12	31	11	29	3	15	
5/20/81	2145	10717.0	1.9	12.0	12	33	11	31	3	16	
5/20/81	2200	10717.0	2.0	11.9	12	31	11	29	3	15	
5/20/81	2215	10717.0	1.7	12.1	12	30	11	27	3	15	
5/20/81	2230	10717.0	1.6	12.2	12	30	11	27	3	15	
5/20/81	2245	10717.0	1.7	12.1	13	31	12	28	3	15	
5/20/81	2300	10717.0	1.1	12.6	720	19	650	17	214	9	
5/20/81	2315	10717.0	.4	13.1	1500	4	1509	3	431	1	
5/20/81	2330	10717.0	.5	13.0	1500	11	1316	9	433	5	
5/20/81	2345	10717.0	3.7	10.7	22	43	22	44	7	24	
5/20/81	2400	10717.0	3.5	10.9	16	45	16	46	5	25	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/21/81	15	10717.0	3.1	11.2	14	43	14	43	4	23	
5/21/81	30	10717.0	3.3	11.0	12	44	12	44	4	24	
5/21/81	45	10717.0	3.3	11.1	12	44	12	44	4	24	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
5/21/81	115	10717.0	3.3	11.0	12	44	12	44	4	24	
5/21/81	130	10717.0	3.4	11.0	12	44	12	45	4	24	
5/21/81	145	10717.0	3.1	11.6	11	43	11	43	3	23	
5/21/81	200	10717.0	3.3	11.0	12	43	12	43	4	23	
5/21/81	215	10717.0	3.4	11.0	12	44	12	45	4	24	
5/21/81	230	10717.0	3.6	11.0	12	44	12	45	4	24	
5/21/81	245	10717.0	3.4	11.0	12	44	12	45	4	24	
5/21/81	300	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	315	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	330	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	345	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	400	10717.0	3.3	11.1	12	45	12	45	4	24	
5/21/81	415	10717.0	3.3	11.1	12	45	12	45	4	24	
5/21/81	430	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	445	10717.0	3.3	11.0	12	44	12	44	4	24	
5/21/81	500	10717.0	3.3	11.0	12	44	12	44	4	24	
5/21/81	515	10717.0	3.3	11.0	12	44	12	44	4	24	
5/21/81	530	10717.0	3.1	11.1	12	43	12	43	3	23	
5/21/81	545	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	600	10717.0	3.2	11.0	12	44	12	44	3	24	
5/21/81	615	10717.0	3.2	11.1	11	44	11	44	3	24	
5/21/81	630	10717.0	3.5	11.0	11	45	11	46	3	25	
5/21/81	645	10717.0	3.5	11.0	11	45	11	46	3	25	
5/21/81	700	10717.0	3.5	11.0	11	45	11	46	3	25	
5/21/81	715	10717.0	3.3	11.1	12	44	12	44	4	24	
5/21/81	730	10717.0	3.3	10.0	11	45	11	45	3	24	
5/21/81	745	10717.0	3.5	11.0	12	45	12	46	4	25	
5/21/81	800	10717.0	3.5	11.0	12	45	12	46	4	25	
5/21/81	815	10717.0	3.5	11.0	12	45	12	46	4	25	
5/21/81	830	10717.0	3.4	11.1	12	44	12	45	4	24	
5/21/81	845	10717.0	3.2	11.2	12	42	12	42	3	23	
5/21/81	900	10717.0	3.4	11.0	12	44	12	45	4	24	
5/21/81	915	10717.0	3.4	11.1	11	45	11	46	3	24	
5/21/81	930	10717.0	3.5	11.0	11	45	11	46	3	25	
5/21/81	945	10717.0	3.4	11.1	12	45	12	46	4	24	
5/21/81	1000	10717.0	3.3	11.2	12	44	12	44	4	24	
5/21/81	1015	10717.0	3.1	11.2	11	45	11	45	3	24	
5/21/81	1030	10717.0	3.2	11.2	11	45	11	45	3	24	
5/21/81	1045	10717.0	3.0	11.4	10	42	10	42	3	22	
5/21/81	1100	10717.0	.0	.0	0	0	0	0	0	0	C
5/21/81	1115	10717.0	3.0	10.6	40	54	40	54	13	29	
5/21/81	1130	10717.0	2.8	11.1	9	42	8	41	2	22	
5/21/81	1145	10717.0	3.8	11.0	5	43	5	45	1	24	
5/21/81	1200	10717.0	3.0	11.0	6	43	6	43	1	23	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/21/81	1215	10717.0	3.0	11.4	6	43	6	43	1	23	
5/21/81	1230	10717.0	3.0	11.4	7	43	7	43	2	23	
5/21/81	1245	10717.0	.0	.0	0	0	0	0	0	0	C
5/21/81	1300	10717.0	2.0	12.0	3	43	2	40	0	22	
5/21/81	1315	10717.0	3.0	11.4	9	43	9	43	2	23	
5/21/81	1330	10717.0	2.8	11.5	9	42	8	41	2	22	
5/21/81	1345	10717.0	1.7	12.2	11	30	10	27	3	15	
5/21/81	1400	10717.0	1.1	12.6	0	26	0	23	0	12	
5/21/81	1415	10717.0	1.4	12.4	12	28	11	25	3	13	
5/21/81	1430	10717.0	1.1	12.6	30	26	27	23	8	12	
5/21/81	1445	10717.0	1.3	12.4	12	27	10	24	3	13	
5/21/81	1500	10717.0	1.4	12.4	12	27	11	24	3	13	
5/21/81	1515	10717.0	1.4	12.4	12	28	11	25	3	13	
5/21/81	1530	10717.0	1.3	12.4	12	27	10	24	3	13	
5/21/81	1545	10717.0	1.4	12.4	12	28	11	25	3	13	
5/21/81	1600	10717.0	1.3	12.4	11	27	10	24	3	13	
5/21/81	1615	10717.0	1.2	12.5	12	26	10	23	3	12	
5/21/81	1630	10717.0	1.3	12.4	11	27	10	24	3	13	
5/21/81	1645	10717.0	1.3	12.4	11	27	10	24	3	13	
5/21/81	1700	10717.0	1.2	12.5	11	26	9	23	3	12	
5/21/81	1715	10717.0	1.2	12.5	6	26	5	23	1	12	
5/21/81	1730	10717.0	1.1	12.5	4	25	3	22	1	12	
5/21/81	1745	10717.0	1.3	12.5	4	27	3	24	1	13	
5/21/81	1800	10717.0	1.3	12.5	7	27	6	24	2	13	
5/21/81	1815	10717.0	1.1	12.5	0	26	0	23	0	12	
5/21/81	1830	10717.0	1.4	12.3	0	28	0	25	0	13	
5/21/81	1845	10717.0	1.1	12.5	0	26	0	23	0	12	
5/21/81	1900	10717.0	1.1	12.6	0	26	0	23	0	12	
5/21/81	1915	10717.0	1.3	12.5	0	27	0	24	0	13	
5/21/81	1930	10717.0	1.2	12.5	0	26	0	23	0	12	
5/21/81	1945	10717.0	1.2	12.5	0	26	0	23	0	12	
5/21/81	2000	10717.0	1.3	12.5	0	27	0	24	0	13	
5/21/81	2015	10717.0	1.3	12.5	0	27	0	24	0	13	
5/21/81	2030	10717.0	1.4	12.4	0	28	0	25	0	13	
5/21/81	2045	10717.0	1.4	12.4	0	28	0	25	0	13	
5/21/81	2100	10717.0	1.4	12.4	0	28	0	25	0	13	
5/21/81	2115	10717.0	1.4	12.4	0	28	0	25	0	13	
5/21/81	2130	10717.0	1.4	12.4	10	28	9	25	3	13	
5/21/81	2145	10717.0	1.4	12.4	10	28	9	25	3	13	
5/21/81	2200	10717.0	1.4	12.4	10	29	9	26	3	14	
5/21/81	2215	10717.0	1.4	12.4	10	28	9	25	3	13	
5/21/81	2230	10717.0	1.6	12.3	10	29	9	26	3	14	
5/21/81	2245	10717.0	1.4	12.4	10	28	9	25	3	13	
5/21/81	2300	10717.0	1.3	12.4	10	27	9	24	3	13	
5/21/81	2315	10717.0	1.4	12.4	10	28	9	25	3	13	
5/21/81	2330	10717.0	1.4	12.4	10	28	9	25	3	13	
5/21/81	2345	10717.0	1.5	12.3	11	28	10	25	3	14	
5/21/81	2400	10717.0	1.5	12.3	11	29	10	26	3	14	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL

15 MIN. DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/22/81	15	10717.0	1.5	12.3	11	29	10	26	3	14	
5/22/81	30	10717.0	1.6	12.3	12	29	11	26	3	14	
5/22/81	45	10717.0	1.5	12.3	11	28	10	25	3	14	
5/22/81	100	10717.0	1.4	12.4	12	28	11	25	3	13	
5/22/81	115	10717.0	1.4	12.4	12	27	11	24	3	13	
5/22/81	130	10717.0	1.3	12.5	11	26	10	23	3	12	
5/22/81	145	10717.0	1.4	12.4	11	27	10	24	3	13	
5/22/81	200	10717.0	1.3	12.4	12	27	10	24	3	13	
5/22/81	215	10717.0	1.3	12.4	16	25	14	22	4	12	
5/22/81	230	10717.0	1.5	12.3	15	27	13	24	4	13	
5/22/81	245	10717.0	1.6	12.2	17	28	15	25	5	14	
5/22/81	300	10717.0	1.4	12.3	16	27	14	24	4	13	
5/22/81	315	10717.0	1.4	12.4	16	27	14	24	4	13	
5/22/81	330	10717.0	1.5	12.3	16	27	14	24	4	13	
5/22/81	345	10717.0	1.6	12.2	16	28	14	25	4	14	
5/22/81	400	10717.0	1.4	12.4	17	27	15	24	5	13	
5/22/81	415	10717.0	1.5	12.3	17	27	15	24	5	13	
5/22/81	430	10717.0	1.5	12.3	16	27	14	24	4	13	
5/22/81	445	10717.0	1.5	12.3	17	27	15	24	5	13	
5/22/81	500	10717.0	1.7	12.2	16	28	14	26	4	14	
5/22/81	515	10717.0	1.5	12.3	16	27	14	24	4	13	
5/22/81	530	10717.0	1.5	12.3	17	27	15	24	5	13	
5/22/81	545	10717.0	1.7	12.2	17	29	15	27	5	14	
5/22/81	600	10717.0	1.6	12.2	16	28	14	25	4	14	
5/22/81	615	10717.0	1.6	12.3	17	28	15	25	5	14	
5/22/81	630	10717.0	1.6	12.2	16	27	14	25	4	13	
5/22/81	645	10717.0	1.3	12.4	16	26	14	23	4	12	
5/22/81	700	10717.0	1.3	12.4	15	26	13	23	4	12	
5/22/81	715	10717.0	1.4	12.4	17	26	15	23	5	12	
5/22/81	730	10717.0	1.6	12.3	17	27	15	25	5	13	
5/22/81	745	10717.0	1.6	12.3	16	27	14	25	4	13	
5/22/81	800	10717.0	1.4	12.3	17	26	15	23	5	12	
5/22/81	815	10717.0	1.8	12.1	17	28	15	26	5	14	
5/22/81	830	10717.0	1.6	12.2	17	28	15	25	5	14	
5/22/81	845	10717.0	.9	12.8	800	17	715	15	235	8	
5/22/81	900	10717.0	1.1	12.6	1130	13	1021	11	336	6	
5/22/81	915	10717.0	4.2	10.5	49	47	52	50	17	27	
5/22/81	930	10717.0	3.8	10.8	20	52	20	54	6	29	
5/22/81	945	10717.0	3.6	10.9	16	50	16	51	5	28	
5/22/81	1000	10717.0	4.2	10.6	19	52	20	55	6	30	
5/22/81	1015	10717.0	4.1	10.6	18	53	19	56	6	30	
5/22/81	1030	10717.0	4.1	10.6	16	52	17	55	5	30	
5/22/81	1045	10717.0	4.0	10.7	14	53	14	56	4	30	
5/22/81	1100	10717.0	4.0	10.7	12	53	12	56	4	30	
5/22/81	1115	10717.0	3.8	10.9	11	52	11	54	3	29	
5/22/81	1130	10717.0	3.9	10.7	10	53	10	55	3	30	
5/22/81	1145	10717.0	3.8	10.8	12	53	12	55	4	30	
5/22/81	1200	10717.0	3.8	10.8	14	53	14	55	4	30	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/22/81	1215	10717.0	3.9	10.8	18	53	18	55	6	30	
5/22/81	1230	10717.0	3.8	10.8	21	53	21	55	7	30	
5/22/81	1245	10717.0	3.8	10.8	22	52	23	54	7	29	
5/22/81	1300	10717.0	3.8	10.8	22	53	23	55	7	30	
5/22/81	1315	10717.0	3.4	11.1	22	50	22	51	7	27	
5/22/81	1330	10717.0	3.4	11.1	24	50	24	51	8	27	
5/22/81	1345	10717.0	3.7	10.9	22	52	22	54	7	29	
5/22/81	1400	10717.0	3.6	10.9	21	52	21	53	7	29	
5/22/81	1415	10717.0	3.5	11.0	23	51	23	52	7	28	
5/22/81	1430	10717.0	3.7	10.9	25	52	26	54	8	29	
5/22/81	1445	10717.0	3.7	11.0	25	51	26	53	8	28	
5/22/81	1500	10717.0	.0	.0	0	0	0	0	0	0	K
5/22/81	1515	10717.0	.0	.0	0	0	0	0	0	0	K
5/22/81	1530	10717.0	.0	.0	0	0	0	0	0	0	K
5/22/81	1545	10717.0	.0	.0	0	0	0	0	0	0	K
5/22/81	1600	10717.0	2.1	12.0	9	37	8	35	2	19	
5/22/81	1615	10717.0	3.6	10.9	0	53	0	54	0	29	
5/22/81	1630	10717.0	3.6	11.0	0	52	0	53	0	29	
5/22/81	1645	10717.0	3.6	11.0	0	52	0	53	0	29	
5/22/81	1700	10717.0	3.6	10.9	0	54	0	55	0	30	
5/22/81	1715	10717.0	3.5	11.0	0	53	0	54	0	29	
5/22/81	1730	10717.0	3.6	11.0	0	53	0	54	0	29	
5/22/81	1745	10717.0	3.6	11.0	0	53	0	54	0	29	
5/22/81	1800	10717.0	3.4	11.2	0	52	0	53	0	28	
5/22/81	1815	10717.0	1.8	12.2	0	35	0	32	0	17	
5/22/81	1830	10717.0	1.7	12.3	0	34	0	31	0	17	
5/22/81	1845	10717.0	1.6	12.3	0	34	0	31	0	17	
5/22/81	1900	10717.0	1.7	12.3	0	34	0	31	0	17	
5/22/81	1915	10717.0	1.7	12.2	0	34	0	31	0	17	
5/22/81	1930	10717.0	1.7	12.2	0	34	0	31	0	17	
5/22/81	1945	10717.0	1.8	12.1	0	34	0	31	0	17	
5/22/81	2000	10717.0	1.7	12.3	0	33	0	30	0	16	
5/22/81	2015	10717.0	1.7	12.3	0	33	0	30	0	16	
5/22/81	2030	10717.0	1.7	12.3	0	33	0	30	0	16	
5/22/81	2045	10717.0	1.8	12.2	0	33	0	30	0	16	
5/22/81	2100	10717.0	1.8	12.2	0	34	0	31	0	17	
5/22/81	2115	10717.0	1.9	12.1	0	35	0	32	0	17	
5/22/81	2130	10717.0	1.8	12.2	0	34	0	31	0	17	
5/22/81	2145	10717.0	1.5	12.4	0	32	0	29	0	16	
5/22/81	2200	10717.0	1.4	12.5	0	31	0	28	0	15	
5/22/81	2215	10717.0	1.4	12.4	0	32	0	29	0	15	
5/22/81	2230	10717.0	1.3	12.5	0	30	0	27	0	14	
5/22/81	2245	10717.0	.5	13.0	1038	14	910	12	299	6	
5/22/81	2300	10717.0	.3	13.2	1500	3	1303	2	428	1	
5/22/81	2315	10717.0	.3	13.2	1501	6	1304	5	429	2	
5/22/81	2330	10717.0	7.5	8.0	0	37	0	49	0	26	
5/22/81	2345	10717.0	7.9	8.1	3	59	4	81	1	44	
5/22/81	2400	10717.0	8.1	8.1	0	60	0	83	0	45	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/23/81	15	10717.0	8.2	8.1	0	61	0	85	0	46	
5/23/81	30	10717.0	7.9	8.3	0	61	0	83	0	45	
5/23/81	45	10717.0	7.8	8.3	0	61	0	83	0	45	
5/23/81	100	10717.0	7.3	8.6	0	61	0	80	0	43	
5/23/81	115	10717.0	7.5	8.5	0	61	0	81	0	44	
5/23/81	130	10717.0	7.3	8.6	0	61	0	80	0	43	
5/23/81	145	10717.0	7.6	8.4	0	60	0	80	0	43	
5/23/81	200	10717.0	8.2	8.1	0	57	0	80	0	43	
5/23/81	215	10717.0	8.0	8.1	0	59	0	81	0	44	
5/23/81	230	10717.0	8.1	8.1	0	59	0	82	0	44	
5/23/81	245	10717.0	7.8	8.3	0	59	0	80	0	43	
5/23/81	300	10717.0	7.9	8.2	0	60	0	82	0	44	
5/23/81	315	10717.0	8.0	8.1	0	60	0	83	0	45	
5/23/81	330	10717.0	7.9	8.2	0	60	0	82	0	44	
5/23/81	345	10717.0	7.9	8.2	0	60	0	82	0	44	
5/23/81	400	10717.0	7.9	8.2	0	60	0	82	0	44	
5/23/81	415	10717.0	7.9	8.2	0	59	0	81	0	44	
5/23/81	430	10717.0	7.8	8.2	0	58	0	79	0	42	
5/23/81	445	10717.0	7.9	8.2	0	58	0	79	0	43	
5/23/81	500	10717.0	7.9	8.2	0	58	0	79	0	43	
5/23/81	515	10717.0	8.0	8.1	0	58	0	80	0	43	
5/23/81	530	10717.0	8.0	8.1	0	58	0	80	0	43	
5/23/81	545	10717.0	8.0	8.2	0	58	0	80	0	43	
5/23/81	600	10717.0	7.6	8.4	0	58	0	78	0	42	
5/23/81	615	10717.0	7.8	8.3	0	58	0	79	0	42	
5/23/81	630	10717.0	7.7	8.3	0	59	0	80	0	43	
5/23/81	645	10717.0	7.8	8.3	0	59	0	80	0	43	
5/23/81	700	10717.0	7.8	8.3	0	59	0	80	0	43	
5/23/81	715	10717.0	8.0	8.2	0	58	0	80	0	43	
5/23/81	730	10717.0	8.0	8.2	0	59	0	81	0	44	
5/23/81	745	10717.0	7.9	8.2	0	59	0	81	0	44	
5/23/81	800	10717.0	7.5	8.5	0	59	0	78	0	42	
5/23/81	815	10717.0	4.0	10.8	0	50	0	52	0	25	
5/23/81	830	10717.0	2.8	11.4	0	42	0	41	0	22	
5/23/81	845	10717.0	3.4	11.2	0	48	0	49	0	26	
5/23/81	900	10717.0	3.2	11.3	0	48	0	48	0	26	
5/23/81	915	10717.0	3.4	11.2	0	49	0	50	0	27	
5/23/81	930	10717.0	2.8	11.5	0	46	0	45	0	24	
5/23/81	945	10717.0	.0	.0	0	0	0	0	0	0	C
5/23/81	1000	10717.0	3.1	10.9	20	65	20	65	6	35	
5/23/81	1015	10717.0	2.8	11.7	20	47	19	46	6	25	
5/23/81	1030	10717.0	2.9	11.7	20	47	19	46	6	25	
5/23/81	1045	10717.0	2.8	11.7	22	46	21	45	7	24	
5/23/81	1100	10717.0	2.9	11.7	19	47	18	46	6	25	
5/23/81	1115	10717.0	.0	.0	0	0	0	0	0	0	C
5/23/81	1130	10717.0	2.9	11.7	17	47	16	46	5	25	
5/23/81	1145	10717.0	2.3	11.6	17	47	16	45	5	24	
5/23/81	1200	10717.0	2.8	11.6	17	47	16	46	5	25	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/23/81	1215	10717.0	2.7	11.6	17	48	16	47	5	25	
5/23/81	1230	10717.0	2.7	11.6	19	48	18	47	6	25	
5/23/81	1245	10717.0	2.6	11.7	19	48	18	46	6	25	
5/23/81	1300	10717.0	2.7	11.7	20	49	19	48	6	26	
5/23/81	1315	10717.0	2.5	11.7	22	47	21	45	7	24	
5/23/81	1330	10717.0	2.5	11.7	22	47	21	45	7	24	
5/23/81	1345	10717.0	2.4	11.8	23	46	22	44	7	24	
5/23/81	1400	10717.0	2.6	11.7	22	47	21	45	7	24	
5/23/81	1415	10717.0	2.4	11.8	25	46	24	44	7	24	
5/23/81	1430	10717.0	1.9	12.0	11	42	10	39	3	21	
5/23/81	1445	10717.0	1.7	12.2	27	39	25	36	8	19	
5/23/81	1500	10717.0	1.8	12.1	18	41	16	38	5	20	
5/23/81	1515	10717.0	2.1	12.0	18	45	17	42	5	23	
5/23/81	1530	10717.0	2.0	12.0	17	45	16	42	5	23	
5/23/81	1545	10717.0	2.1	12.0	16	46	15	43	5	23	
5/23/81	1600	10717.0	2.1	12.0	16	46	15	43	5	23	
5/23/81	1615	10717.0	2.2	12.0	16	46	15	44	5	23	
5/23/81	1630	10717.0	2.2	12.0	24	46	22	44	7	23	
5/23/81	1645	10717.0	2.1	12.0	20	46	19	43	6	23	
5/23/81	1700	10717.0	2.1	12.0	18	46	17	43	5	23	
5/23/81	1715	10717.0	2.1	12.0	18	45	17	42	5	23	
5/23/81	1730	10717.0	2.1	12.0	22	45	20	42	6	23	
5/23/81	1745	10717.0	2.1	12.0	20	45	19	42	6	23	
5/23/81	1800	10717.0	2.0	12.0	19	44	17	41	5	22	
5/23/81	1815	10717.0	2.0	12.1	18	43	17	40	5	22	
5/23/81	1830	10717.0	2.1	12.0	20	44	19	41	6	22	
5/23/81	1845	10717.0	.0	.0	0	0	0	0	0	0	K
5/23/81	1900	10717.0	.0	.0	0	0	0	0	0	0	K
5/23/81	1915	10717.0	.0	.0	0	0	0	0	0	0	K
5/23/81	1930	10717.0	.0	.0	0	0	0	0	0	0	K
5/23/81	1945	10717.0	.0	.0	0	0	0	0	0	0	K
5/23/81	2000	10717.0	.0	.0	0	0	0	0	0	0	K
5/23/81	2015	10717.0	2.0	12.1	22	43	20	40	6	22	
5/23/81	2030	10717.0	2.1	12.1	23	43	21	40	7	22	
5/23/81	2045	10717.0	2.1	12.0	22	43	20	40	6	22	
5/23/81	2100	10717.0	2.1	12.0	22	43	20	40	6	22	
5/23/81	2115	10717.0	2.2	12.0	22	44	21	42	6	22	
5/23/81	2130	10717.0	2.2	12.0	22	44	21	42	6	22	
5/23/81	2145	10717.0	2.2	11.9	22	44	21	42	6	22	
5/23/81	2200	10717.0	2.2	11.9	22	44	21	42	6	22	
5/23/81	2215	10717.0	2.2	12.0	23	44	22	42	7	22	
5/23/81	2230	10717.0	2.3	11.9	22	44	21	42	6	22	
5/23/81	2245	10717.0	2.1	12.0	21	43	19	40	6	22	
5/23/81	2300	10717.0	2.2	11.9	22	44	21	42	6	22	
5/23/81	2315	10717.0	2.1	12.0	22	43	20	40	6	22	
5/23/81	2330	10717.0	2.0	12.1	22	41	20	38	6	21	
5/23/81	2345	10717.0	2.2	12.0	23	42	22	40	7	21	
5/23/81	2400	10717.0	2.3	11.8	24	45	23	43	7	23	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/24/81	15	10717.0	2.1	12.0	19	43	18	40	5	22	
5/24/81	30	10717.0	2.1	12.0	19	42	18	39	5	21	
5/24/81	45	10717.0	2.0	12.0	20	43	18	40	6	22	
5/24/81	100	10717.0	2.0	12.0	22	43	20	40	6	22	
5/24/81	115	10717.0	2.0	12.0	21	43	19	40	6	22	
5/24/81	130	10717.0	2.0	12.0	23	43	21	40	7	22	
5/24/81	145	10717.0	2.0	12.0	20	42	18	39	6	21	
5/24/81	200	10717.0	2.1	12.0	21	42	19	39	6	21	
5/24/81	215	10717.0	2.0	12.0	20	42	18	39	6	21	
5/24/81	230	10717.0	2.0	12.0	22	42	20	39	6	21	
5/24/81	245	10717.0	2.0	12.1	23	42	21	39	7	21	
5/24/81	300	10717.0	2.1	12.0	20	42	19	39	6	21	
5/24/81	315	10717.0	2.1	12.0	20	42	19	39	6	21	
5/24/81	330	10717.0	2.1	12.0	21	43	19	40	6	22	
5/24/81	345	10717.0	2.1	12.0	21	43	19	40	6	22	
5/24/81	400	10717.0	2.0	12.0	21	43	19	40	6	22	
5/24/81	415	10717.0	2.0	11.9	21	44	19	41	6	22	
5/24/81	430	10717.0	2.1	11.9	21	44	19	41	6	22	
5/24/81	445	10717.0	2.2	11.9	22	44	21	42	6	22	
5/24/81	500	10717.0	2.2	11.9	22	43	21	41	6	22	
5/24/81	515	10717.0	2.2	11.9	22	44	21	42	6	22	
5/24/81	530	10717.0	2.3	11.9	23	44	22	42	7	22	
5/24/81	545	10717.0	2.2	11.9	24	44	22	42	7	22	
5/24/81	600	10717.0	2.2	11.9	23	43	22	41	7	22	
5/24/81	615	10717.0	2.2	11.9	19	43	18	41	5	22	
5/24/81	630	10717.0	2.2	11.9	20	43	19	41	6	22	
5/24/81	645	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	700	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	715	10717.0	2.1	12.0	21	43	19	40	6	22	
5/24/81	730	10717.0	2.1	12.0	20	43	19	40	6	22	
5/24/81	745	10717.0	2.1	12.0	20	42	19	39	6	21	
5/24/81	800	10717.0	2.0	12.0	20	42	18	39	6	21	
5/24/81	815	10717.0	1.9	12.1	19	43	17	40	5	21	
5/24/81	830	10717.0	2.4	11.8	19	43	18	41	6	22	
5/24/81	845	10717.0	2.3	11.9	18	42	17	40	5	21	
5/24/81	900	10717.0	2.1	12.0	17	42	16	39	5	21	
5/24/81	915	10717.0	2.0	12.0	17	41	16	38	5	21	
5/24/81	930	10717.0	2.0	12.0	18	42	17	39	5	21	
5/24/81	945	10717.0	1.9	12.1	20	41	18	38	6	20	
5/24/81	1000	10717.0	1.8	12.2	20	41	18	38	6	20	
5/24/81	1015	10717.0	1.8	12.2	20	41	18	38	6	20	
5/24/81	1030	10717.0	2.0	12.0	20	41	18	38	6	21	
5/24/81	1045	10717.0	2.0	12.0	21	42	19	39	6	21	
5/24/81	1100	10717.0	2.1	12.0	19	42	18	39	5	21	
5/24/81	1115	10717.0	2.1	12.0	18	42	17	39	5	21	
5/24/81	1130	10717.0	2.1	12.0	19	42	18	39	5	21	
5/24/81	1145	10717.0	2.0	12.0	19	42	17	39	5	21	
5/24/81	1200	10717.0	2.0	12.0	19	42	17	39	5	21	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/24/81	1215	10717.0	2.1	12.0	20	41	19	39	6	21	
5/24/81	1230	10717.0	2.2	11.9	22	40	21	38	6	20	
5/24/81	1245	10717.0	2.2	11.9	21	40	20	38	6	20	
5/24/81	1300	10717.0	2.1	12.0	21	41	19	39	6	21	
5/24/81	1315	10717.0	2.2	11.9	21	41	20	39	6	21	
5/24/81	1330	10717.0	2.2	11.9	22	43	21	41	6	22	
5/24/81	1345	10717.0	2.3	11.9	22	43	21	41	6	22	
5/24/81	1400	10717.0	2.5	11.8	22	45	21	43	7	23	
5/24/81	1415	10717.0	2.5	11.8	22	46	21	44	7	24	
5/24/81	1430	10717.0	2.4	11.8	22	46	21	44	7	24	
5/24/81	1445	10717.0	2.3	11.9	21	46	20	44	6	24	
5/24/81	1500	10717.0	2.2	11.9	21	44	20	42	6	22	
5/24/81	1515	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	1530	10717.0	2.3	11.8	22	45	21	43	6	23	
5/24/81	1545	10717.0	2.2	12.0	22	44	21	42	6	22	
5/24/81	1600	10717.0	2.4	11.8	22	45	21	43	7	23	
5/24/81	1615	10717.0	2.3	11.9	21	45	20	43	6	23	
5/24/81	1630	10717.0	2.3	11.9	22	45	21	43	6	23	
5/24/81	1645	10717.0	2.2	11.9	22	44	21	42	6	22	
5/24/81	1700	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	1715	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	1730	10717.0	2.1	12.0	21	45	19	42	6	23	
5/24/81	1745	10717.0	2.1	12.0	21	45	19	42	6	23	
5/24/81	1800	10717.0	2.2	11.9	21	45	20	43	6	23	
5/24/81	1815	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	1830	10717.0	2.0	12.1	21	44	19	41	6	22	
5/24/81	1845	10717.0	2.0	12.0	21	44	19	41	6	22	
5/24/81	1900	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	1915	10717.0	2.0	12.0	21	43	19	40	6	22	
5/24/81	1930	10717.0	2.0	12.0	21	43	19	40	6	22	
5/24/81	1945	10717.0	2.1	12.0	21	44	19	41	6	22	
5/24/81	2000	10717.0	2.2	11.9	21	44	20	42	6	22	
5/24/81	2015	10717.0	2.2	11.9	22	44	21	42	6	22	
5/24/81	2030	10717.0	2.2	11.9	22	44	21	42	6	22	
5/24/81	2045	10717.0	2.1	12.0	22	44	20	41	6	22	
5/24/81	2100	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2115	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2130	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2145	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2200	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2215	10717.0	2.3	11.8	25	43	24	41	7	22	
5/24/81	2230	10717.0	2.2	11.9	25	43	23	41	7	22	
5/24/81	2245	10717.0	2.2	11.9	25	42	23	40	7	21	
5/24/81	2300	10717.0	2.3	11.9	24	43	23	41	7	22	
5/24/81	2315	10717.0	2.2	11.9	24	43	22	41	7	22	
5/24/81	2330	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2345	10717.0	.0	.0	0	0	0	0	0	0	K
5/24/81	2400	10717.0	.0	.0	0	0	0	0	0	0	K

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/25/81	15	10717.0	.0	.0	0	0	0	0	0	0	K
5/25/81	30	10717.0	.0	.0	0	0	0	0	0	0	K
5/25/81	45	10717.0	2.0	12.2	25	40	23	37	7	20	
5/25/81	100	10717.0	2.2	12.0	25	41	23	39	7	21	
5/25/81	115	10717.0	2.2	12.0	25	40	23	38	7	20	
5/25/81	130	10717.0	2.3	11.9	24	42	23	40	7	21	
5/25/81	145	10717.0	2.4	11.8	25	43	24	41	7	22	
5/25/81	200	10717.0	2.5	11.8	24	44	23	42	7	23	
5/25/81	215	10717.0	2.5	11.8	24	44	23	42	7	23	
5/25/81	230	10717.0	2.7	11.6	24	46	23	45	7	24	
5/25/81	245	10717.0	2.5	11.7	24	44	23	42	7	23	
5/25/81	300	10717.0	2.4	11.9	24	43	23	41	7	22	
5/25/81	315	10717.0	2.7	11.7	24	44	23	43	7	23	
5/25/81	330	10717.0	2.5	11.7	24	44	23	42	7	23	
5/25/81	345	10717.0	2.3	11.9	24	43	23	41	7	22	
5/25/81	400	10717.0	2.3	11.9	23	43	22	41	7	22	
5/25/81	415	10717.0	2.1	12.0	24	41	22	39	7	21	
5/25/81	430	10717.0	2.3	11.8	24	43	23	41	7	22	
5/25/81	445	10717.0	2.3	11.9	24	43	23	41	7	22	
5/25/81	500	10717.0	2.3	11.9	23	42	22	40	7	21	
5/25/81	515	10717.0	2.1	12.0	24	41	22	39	7	21	
5/25/81	530	10717.0	2.2	12.0	23	42	22	40	7	21	
5/25/81	545	10717.0	2.1	12.0	24	42	22	39	7	21	
5/25/81	600	10717.0	.0	.0	0	0	0	0	0	0	K
5/25/81	615	10717.0	.0	.0	0	0	0	0	0	0	K
5/25/81	630	10717.0	.0	.0	0	0	0	0	0	0	K
5/25/81	645	10717.0	2.3	11.9	24	43	23	41	7	22	
5/25/81	700	10717.0	2.3	11.9	24	43	23	41	7	22	
5/25/81	715	10717.0	2.3	11.9	24	44	23	42	7	22	
5/25/81	730	10717.0	2.5	11.9	23	45	22	43	7	23	
5/25/81	745	10717.0	2.5	11.8	24	45	23	43	7	23	
5/25/81	800	10717.0	2.5	11.8	24	44	23	42	7	23	
5/25/81	815	10717.0	2.3	11.9	23	43	22	41	7	22	
5/25/81	830	10717.0	2.4	11.8	23	44	22	42	7	23	
5/25/81	845	10717.0	2.6	11.7	23	46	22	44	7	24	
5/25/81	900	10717.0	.7	12.9	1155	16	1023	14	336	7	
5/25/81	915	10717.0	.4	13.1	1500	5	1309	4	431	2	
5/25/81	930	10717.0	.4	13.1	1500	5	1309	4	431	2	
5/25/81	945	10717.0	.4	13.1	1500	5	1309	4	431	2	
5/25/81	1000	10717.0	1.1	12.6	1400	11	1265	9	416	5	
5/25/81	1015	10717.0	2.7	11.2	384	36	377	35	124	19	
5/25/81	1030	10717.0	3.6	11.0	34	44	35	45	11	24	
5/25/81	1045	10717.0	3.9	10.8	26	47	27	49	9	26	
5/25/81	1100	10717.0	3.9	10.8	26	46	27	48	9	26	
5/25/81	1115	10717.0	4.1	10.7	25	47	26	50	8	27	
5/25/81	1130	10717.0	3.9	10.8	24	46	25	48	8	26	
5/25/81	1145	10717.0	4.1	10.7	23	47	24	50	8	27	
5/25/81	1200	10717.0	4.2	10.6	23	47	24	50	8	27	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/25/81	1215	10717.0	4.2	10.6	23	47	24	50	8	27	
5/25/81	1230	10717.0	4.2	10.6	23	47	24	50	8	27	
5/25/81	1245	10717.0	4.2	10.6	22	47	23	50	7	27	
5/25/81	1300	10717.0	4.2	10.6	23	47	24	50	8	27	
5/25/81	1315	10717.0	4.1	10.7	23	48	24	51	8	27	
5/25/81	1330	10717.0	4.1	10.6	23	47	24	50	8	27	
5/25/81	1345	10717.0	4.0	10.7	22	47	23	49	7	27	
5/25/81	1400	10717.0	4.0	10.7	22	47	23	49	7	27	
5/25/81	1415	10717.0	4.0	10.7	23	48	24	50	8	27	
5/25/81	1430	10717.0	3.9	10.8	22	46	23	48	7	26	
5/25/81	1445	10717.0	4.1	10.7	22	47	23	50	7	27	
5/25/81	1500	10717.0	3.9	10.8	8	45	8	47	2	25	
5/25/81	1515	10717.0	.0	.0	0	0	0	0	0	0	C
5/25/81	1530	10717.0	3.9	10.9	6	44	6	46	2	25	
5/25/81	1545	10717.0	4.0	10.9	6	45	6	47	2	25	
5/25/81	1600	10717.0	4.0	10.9	7	46	7	48	2	26	
5/25/81	1615	10717.0	3.8	11.0	7	45	7	47	2	25	
5/25/81	1630	10717.0	3.9	10.9	7	46	7	48	2	26	
5/25/81	1645	10717.0	4.1	10.8	6	46	6	49	2	26	
5/25/81	1700	10717.0	4.0	11.0	6	46	6	48	2	26	
5/25/81	1715	10717.0	3.8	11.0	6	45	6	47	2	25	
5/25/81	1730	10717.0	3.9	11.0	6	45	6	47	2	25	
5/25/81	1745	10717.0	4.1	10.8	5	47	5	50	1	27	
5/25/81	1800	10717.0	4.0	10.9	5	46	5	48	1	26	
5/25/81	1815	10717.0	4.0	10.9	5	46	5	48	1	26	
5/25/81	1830	10717.0	4.1	10.8	5	47	5	50	1	27	
5/25/81	1845	10717.0	4.2	10.8	5	47	5	50	1	27	
5/25/81	1900	10717.0	4.2	10.6	3	47	3	50	1	27	
5/25/81	1915	10717.0	4.2	10.7	5	48	5	51	1	27	
5/25/81	1930	10717.0	4.0	10.8	2	47	2	49	0	27	
5/25/81	1945	10717.0	3.9	11.0	5	46	5	48	1	26	
5/25/81	2000	10717.0	4.0	10.8	5	47	5	49	1	27	
5/25/81	2015	10717.0	3.9	10.9	5	47	5	49	1	26	
5/25/81	2030	10717.0	3.9	10.9	5	46	5	48	1	26	
5/25/81	2045	10717.0	4.0	10.8	5	47	5	49	1	27	
5/25/81	2100	10717.0	3.9	11.0	5	45	5	47	1	25	
5/25/81	2115	10717.0	3.6	11.2	5	43	5	44	1	24	
5/25/81	2130	10717.0	4.0	10.8	5	46	5	48	1	26	
5/25/81	2145	10717.0	4.0	10.9	5	45	5	47	1	25	
5/25/81	2200	10717.0	4.1	10.8	5	45	5	47	1	26	
5/25/81	2215	10717.0	4.1	10.8	5	46	5	49	1	26	
5/25/81	2230	10717.0	4.0	10.9	5	45	5	47	1	25	
5/25/81	2245	10717.0	4.1	10.8	5	46	5	49	1	26	
5/25/81	2300	10717.0	4.1	10.8	6	46	6	49	2	26	
5/25/81	2315	10717.0	4.2	10.8	6	46	6	49	2	26	
5/25/81	2330	10717.0	4.1	10.8	6	46	6	49	2	26	
5/25/81	2345	10717.0	4.2	10.7	6	47	6	50	2	27	
5/25/81	2400	10717.0	4.3	10.6	5	47	5	50	1	27	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/26/81	15	10717.0	4.4	10.6	6	47	6	50	2	27	
5/26/81	30	10717.0	4.3	10.6	6	47	6	50	2	27	
5/26/81	45	10717.0	4.1	10.8	5	46	5	49	1	26	
5/26/81	100	10717.0	4.2	10.7	5	46	5	49	1	26	
5/26/81	115	10717.0	4.2	10.8	5	46	5	49	1	26	
5/26/81	130	10717.0	4.2	10.7	6	46	6	49	2	26	
5/26/81	145	10717.0	4.4	10.6	5	46	5	49	1	27	
5/26/81	200	10717.0	4.2	10.7	6	44	6	47	2	25	
5/26/81	215	10717.0	4.2	10.7	6	44	6	47	2	25	
5/26/81	230	10717.0	4.2	10.7	6	44	6	47	2	25	
5/26/81	245	10717.0	4.2	10.7	6	45	6	48	2	26	
5/26/81	300	10717.0	4.1	10.8	6	45	6	47	2	26	
5/26/81	315	10717.0	4.2	10.7	5	46	5	49	1	26	
5/26/81	330	10717.0	4.2	10.6	5	46	5	49	1	26	
5/26/81	345	10717.0	4.0	10.8	0	44	0	46	0	25	
5/26/81	400	10717.0	4.0	10.8	4	44	4	46	1	25	
5/26/81	415	10717.0	4.0	10.8	5	44	5	46	1	25	
5/26/81	430	10717.0	4.1	10.7	4	44	4	46	1	25	
5/26/81	445	10717.0	4.3	10.6	4	45	4	48	1	26	
5/26/81	500	10717.0	4.1	10.7	4	44	4	46	1	25	
5/26/81	515	10717.0	4.3	10.6	4	45	4	48	1	26	
5/26/81	530	10717.0	4.3	10.6	1	45	1	48	0	26	
5/26/81	545	10717.0	4.1	10.7	4	45	4	47	1	26	
5/26/81	600	10717.0	4.2	10.7	4	45	4	48	1	26	
5/26/81	615	10717.0	4.3	10.6	5	45	5	48	1	26	
5/26/81	630	10717.0	4.4	10.6	3	46	3	49	1	27	
5/26/81	645	10717.0	4.3	10.6	4	46	4	49	1	26	
5/26/81	700	10717.0	4.2	10.7	4	45	4	48	1	26	
5/26/81	715	10717.0	4.3	10.7	4	46	4	49	1	26	
5/26/81	730	10717.0	4.4	10.5	4	46	4	49	1	27	
5/26/81	745	10717.0	4.2	10.7	3	45	3	48	1	26	
5/26/81	800	10717.0	4.2	10.7	4	45	4	48	1	26	
5/26/81	815	10717.0	4.2	10.7	4	45	4	48	1	26	
5/26/81	830	10717.0	3.9	10.9	4	43	4	45	1	24	
5/26/81	845	10717.0	4.4	10.6	3	46	3	49	1	27	
5/26/81	900	10717.0	4.4	10.5	4	46	4	49	1	27	
5/26/81	915	10717.0	4.3	10.6	3	46	3	49	1	26	
5/26/81	930	10717.0	4.5	10.5	3	47	3	51	1	27	
5/26/81	945	10717.0	4.7	10.3	2	48	2	53	0	28	
5/26/81	1000	10717.0	4.6	10.4	3	48	3	52	1	28	
5/26/81	1015	10717.0	4.7	10.4	2	49	2	54	0	29	
5/26/81	1030	10717.0	4.5	10.5	0	48	0	52	0	28	
5/26/81	1045	10717.0	.0	.0	0	0	0	0	0	0	C
5/26/81	1100	10717.0	.0	.0	0	0	0	0	0	0	C
5/26/81	1115	10717.0	4.2	10.7	11	47	11	50	3	27	
5/26/81	1130	10717.0	4.3	10.7	11	46	11	49	3	26	
5/26/81	1145	10717.0	4.4	10.5	11	46	11	49	3	27	
5/26/81	1200	10717.0	4.3	10.6	10	46	10	49	3	26	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN, DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/26/81	1215	10717.0	4.3	10.6	10	45	10	48	3	26	
5/26/81	1230	10717.0	4.2	10.7	10	44	10	47	3	25	
5/26/81	1245	10717.0	4.2	10.7	10	45	10	48	3	26	
5/26/81	1300	10717.0	4.2	10.7	10	44	10	47	3	25	
5/26/81	1315	10717.0	4.2	10.7	10	45	10	48	3	26	
5/26/81	1330	10717.0	4.3	10.6	10	46	10	49	3	26	
5/26/81	1345	10717.0	4.2	10.7	9	46	9	49	3	26	
5/26/81	1400	10717.0	4.3	10.6	9	46	9	49	3	26	
5/26/81	1415	10717.0	4.1	10.8	10	45	10	47	3	26	
5/26/81	1430	10717.0	4.1	10.8	9	46	9	49	3	26	
5/26/81	1445	10717.0	4.2	10.7	9	47	9	50	3	27	
5/26/81	1500	10717.0	4.0	10.8	9	46	9	48	3	26	
5/26/81	1515	10717.0	4.3	10.6	10	47	10	50	3	27	
5/26/81	1530	10717.0	4.2	10.7	10	47	10	50	3	27	
5/26/81	1545	10717.0	4.1	10.7	9	47	9	50	3	27	
5/26/81	1600	10717.0	4.1	10.7	9	46	9	49	3	26	
5/26/81	1615	10717.0	4.0	10.8	10	46	10	48	3	26	
5/26/81	1630	10717.0	4.1	10.8	10	47	10	50	3	27	
5/26/81	1645	10717.0	4.1	10.8	10	46	10	49	3	26	
5/26/81	1700	10717.0	4.1	10.7	10	46	10	49	3	26	
5/26/81	1715	10717.0	4.0	10.8	10	45	10	47	3	25	
5/26/81	1730	10717.0	4.2	10.7	10	46	10	49	3	26	
5/26/81	1745	10717.0	4.1	10.8	10	45	10	47	3	26	
5/26/81	1800	10717.0	4.1	10.7	11	46	11	49	3	26	
5/26/81	1815	10717.0	4.0	10.8	10	45	10	47	3	25	
5/26/81	1830	10717.0	4.0	10.8	11	45	11	47	3	25	
5/26/81	1845	10717.0	4.2	10.7	11	45	11	48	3	26	
5/26/81	1900	10717.0	4.0	10.8	10	45	10	47	3	25	
5/26/81	1915	10717.0	4.2	10.7	10	46	10	49	3	26	
5/26/81	1930	10717.0	4.0	10.8	9	45	9	47	3	25	
5/26/81	1945	10717.0	3.9	10.9	10	43	10	45	3	24	
5/26/81	2000	10717.0	3.8	11.0	12	42	12	43	4	23	
5/26/81	2015	10717.0	4.3	10.7	13	43	14	46	4	25	
5/26/81	2030	10717.0	4.3	10.7	11	43	11	46	3	25	
5/26/81	2045	10717.0	4.3	10.6	11	44	11	47	3	25	
5/26/81	2100	10717.0	4.1	10.8	11	43	11	45	3	24	
5/26/81	2115	10717.0	4.1	10.9	11	42	11	44	3	24	
5/26/81	2130	10717.0	4.0	10.7	11	42	11	44	3	24	
5/26/81	2145	10717.0	4.5	10.6	11	43	12	46	3	25	
5/26/81	2200	10717.0	4.4	10.7	11	43	11	46	3	25	
5/26/81	2215	10717.0	4.5	10.6	10	44	10	48	3	26	
5/26/81	2230	10717.0	4.5	10.6	11	44	12	48	3	26	
5/26/81	2245	10717.0	4.5	10.5	10	45	10	49	3	26	
5/26/81	2300	10717.0	4.5	10.6	10	44	10	48	3	26	
5/26/81	2315	10717.0	4.6	10.5	12	45	13	49	4	26	
5/26/81	2330	10717.0	4.5	10.6	12	45	13	49	4	26	
5/26/81	2345	10717.0	4.6	10.5	12	45	13	49	4	26	
5/26/81	2400	10717.0	4.6	10.5	12	45	13	49	4	26	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/27/81	15	10717.0	4.6	10.5	11	44	12	48	3	26	
5/27/81	30	10717.0	4.5	10.6	11	44	12	48	3	26	
5/27/81	45	10717.0	4.5	10.6	11	44	12	48	3	26	
5/27/81	100	10717.0	4.4	10.6	11	44	11	47	3	25	
5/27/81	115	10717.0	4.5	10.6	11	44	12	48	3	26	
5/27/81	130	10717.0	4.5	10.5	10	44	10	48	3	26	
5/27/81	145	10717.0	4.4	10.6	9	43	9	46	3	25	
5/27/81	200	10717.0	4.4	10.6	10	44	10	47	3	25	
5/27/81	215	10717.0	4.3	10.6	10	44	10	47	3	25	
5/27/81	230	10717.0	4.1	10.8	11	43	11	45	3	24	
5/27/81	245	10717.0	4.7	10.3	11	46	12	50	4	27	
5/27/81	300	10717.0	4.6	10.4	11	45	12	49	3	26	
5/27/81	315	10717.0	4.5	10.5	11	44	12	48	3	26	
5/27/81	330	10717.0	4.7	10.3	9	45	9	49	3	26	
5/27/81	345	10717.0	4.5	10.5	10	44	10	48	3	26	
5/27/81	400	10717.0	4.4	10.6	10	44	10	47	3	25	
5/27/81	415	10717.0	4.4	10.6	10	44	10	47	3	25	
5/27/81	430	10717.0	4.6	10.5	9	44	9	48	3	26	
5/27/81	445	10717.0	4.5	10.5	9	44	9	48	3	26	
5/27/81	500	10717.0	4.4	10.6	9	45	9	48	3	26	
5/27/81	515	10717.0	4.5	10.6	9	45	9	49	3	26	
5/27/81	530	10717.0	4.5	10.5	8	45	8	49	2	26	
5/27/81	545	10717.0	4.5	10.5	8	46	8	50	2	27	
5/27/81	600	10717.0	4.4	10.6	9	45	9	48	3	26	
5/27/81	615	10717.0	4.4	10.6	8	44	8	47	2	25	
5/27/81	630	10717.0	4.4	10.6	8	44	8	47	2	25	
5/27/81	645	10717.0	4.4	10.6	10	44	10	47	3	25	
5/27/81	700	10717.0	4.4	10.6	10	44	10	47	3	25	
5/27/81	715	10717.0	4.4	10.6	9	44	9	47	3	25	
5/27/81	730	10717.0	4.4	10.6	9	44	9	47	3	25	
5/27/81	745	10717.0	4.6	10.5	9	45	9	49	3	26	
5/27/81	800	10717.0	4.4	10.6	8	44	8	47	2	25	
5/27/81	815	10717.0	4.4	10.6	9	44	9	47	3	25	
5/27/81	830	10717.0	4.6	10.5	9	45	9	49	3	26	
5/27/81	845	10717.0	4.1	10.8	10	43	10	45	3	24	
5/27/81	900	10717.0	4.4	10.7	12	44	13	47	4	25	
5/27/81	915	10717.0	4.4	10.6	12	43	13	46	4	25	
5/27/81	930	10717.0	4.2	10.8	10	43	10	46	3	25	
5/27/81	945	10717.0	4.1	10.8	11	43	11	45	3	24	
5/27/81	1000	10717.0	4.0	10.9	11	42	11	44	3	24	
5/27/81	1015	10717.0	.0	.0	0	0	0	0	0	0	C
5/27/81	1030	10717.0	.0	.0	0	0	0	0	0	0	C
5/27/81	1045	10717.0	3.9	10.6	8	42	8	44	2	23	
5/27/81	1100	10717.0	4.0	10.6	7	42	7	44	2	24	
5/27/81	1115	10717.0	4.1	10.5	8	43	8	45	2	24	
5/27/81	1130	10717.0	4.2	10.5	8	44	8	47	2	25	
5/27/81	1145	10717.0	4.0	10.6	9	43	9	45	3	24	
5/27/81	1200	10717.0	4.1	10.5	7	45	7	47	2	26	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/27/81	1215	10717.0	4.0	10.5	7	45	7	47	2	25	
5/27/81	1230	10717.0	4.1	10.5	5	46	5	49	1	26	
5/27/81	1245	10717.0	4.1	10.5	5	46	5	49	1	26	
5/27/81	1300	10717.0	4.1	10.5	7	46	7	49	2	26	
5/27/81	1315	10717.0	4.2	10.4	8	47	8	50	2	27	
5/27/81	1330	10717.0	4.1	10.5	7	47	7	50	2	27	
5/27/81	1345	10717.0	4.1	10.4	7	47	7	50	2	27	
5/27/81	1400	10717.0	4.1	10.4	6	47	6	50	2	27	
5/27/81	1415	10717.0	4.0	10.5	8	46	8	48	2	26	
5/27/81	1430	10717.0	4.2	10.4	6	47	6	50	2	27	
5/27/81	1445	10717.0	4.0	10.5	7	46	7	48	2	26	
5/27/81	1500	10717.0	4.0	10.6	7	46	7	48	2	26	
5/27/81	1515	10717.0	4.2	10.4	8	47	8	50	2	27	
5/27/81	1530	10717.0	4.0	10.5	8	46	8	48	2	26	
5/27/81	1545	10717.0	4.0	10.5	9	45	9	47	3	25	
5/27/81	1600	10717.0	4.0	10.5	9	45	9	47	3	25	
5/27/81	1615	10717.0	3.9	10.6	9	45	9	47	3	25	
5/27/81	1630	10717.0	3.7	10.7	8	44	8	45	2	24	
5/27/81	1645	10717.0	3.7	10.7	8	44	8	45	2	24	
5/27/81	1700	10717.0	3.8	10.6	7	45	7	47	2	25	
5/27/81	1715	10717.0	3.9	10.6	6	45	6	47	2	25	
5/27/81	1730	10717.0	3.9	10.6	8	46	8	48	2	26	
5/27/81	1745	10717.0	3.8	10.7	8	45	8	47	2	25	
5/27/81	1800	10717.0	3.9	10.6	8	46	8	48	2	26	
5/27/81	1815	10717.0	4.0	10.6	7	46	7	48	2	26	
5/27/81	1830	10717.0	4.0	10.6	7	46	7	48	2	26	
5/27/81	1845	10717.0	4.0	10.5	6	47	6	49	2	27	
5/27/81	1900	10717.0	3.9	10.6	6	46	6	48	2	26	
5/27/81	1915	10717.0	3.9	10.6	6	47	6	49	2	26	
5/27/81	1930	10717.0	4.0	10.6	8	47	8	49	2	27	
5/27/81	1945	10717.0	4.0	10.6	8	47	8	49	2	27	
5/27/81	2000	10717.0	4.0	10.5	7	47	7	49	2	27	
5/27/81	2015	10717.0	4.0	10.4	8	47	8	49	2	27	
5/27/81	2030	10717.0	4.0	10.5	9	46	9	48	3	26	
5/27/81	2045	10717.0	4.0	10.6	10	46	10	48	3	26	
5/27/81	2100	10717.0	4.0	10.5	11	46	11	48	3	26	
5/27/81	2115	10717.0	4.0	10.6	11	46	11	48	3	26	
5/27/81	2130	10717.0	4.0	10.5	10	45	10	47	3	25	
5/27/81	2145	10717.0	4.0	10.6	10	45	10	47	3	25	
5/27/81	2200	10717.0	4.0	10.6	9	45	9	47	3	25	
5/27/81	2215	10717.0	4.2	10.5	8	46	8	49	2	26	
5/27/81	2230	10717.0	4.2	10.4	8	47	8	50	2	27	
5/27/81	2245	10717.0	4.2	10.4	8	47	8	50	2	27	
5/27/81	2300	10717.0	4.1	10.5	8	47	8	50	2	27	
5/27/81	2315	10717.0	4.2	10.4	7	46	7	49	2	26	
5/27/81	2330	10717.0	4.1	10.6	7	46	7	49	2	26	
5/27/81	2345	10717.0	4.2	10.4	7	47	7	50	2	27	
5/27/81	2400	10717.0	4.2	10.5	8	46	8	49	2	26	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/28/81	15	10717.0	4.3	10.4	7	47	7	50	2	27	
5/28/81	30	10717.0	4.3	10.4	7	47	7	50	2	27	
5/28/81	45	10717.0	4.2	10.5	7	46	7	49	2	26	
5/28/81	100	10717.0	4.1	10.6	8	46	8	49	2	26	
5/28/81	115	10717.0	4.2	10.4	8	47	8	50	2	27	
5/28/81	130	10717.0	4.2	10.4	7	47	7	50	2	27	
5/28/81	145	10717.0	4.2	10.4	9	46	9	49	3	26	
5/28/81	200	10717.0	4.2	10.4	10	46	10	49	3	26	
5/28/81	215	10717.0	4.1	10.5	11	45	11	47	3	26	
5/28/81	230	10717.0	4.2	10.4	10	45	10	48	3	26	
5/28/81	245	10717.0	4.1	10.5	10	45	10	47	3	26	
5/28/81	300	10717.0	4.0	10.5	10	44	10	46	3	25	
5/28/81	315	10717.0	3.9	10.6	9	44	9	46	3	25	
5/28/81	330	10717.0	3.7	10.7	10	43	10	44	3	24	
5/28/81	345	10717.0	4.4	10.3	10	46	10	49	3	27	
5/28/81	400	10717.0	4.3	10.3	10	46	10	49	3	26	
5/28/81	415	10717.0	4.5	10.2	9	47	9	51	3	27	
5/28/81	430	10717.0	3.3	10.9	2	40	2	40	0	22	
5/28/81	445	10717.0	4.1	10.4	9	45	9	47	3	26	
5/28/81	500	10717.0	4.2	10.3	9	46	9	49	3	26	
5/28/81	515	10717.0	4.3	10.3	9	46	9	49	3	26	
5/28/81	530	10717.0	4.2	10.3	10	46	10	49	3	26	
5/28/81	545	10717.0	4.2	10.4	11	46	11	49	3	26	
5/28/81	600	10717.0	4.2	10.4	11	46	11	49	3	26	
5/28/81	615	10717.0	4.3	10.3	11	47	11	50	3	27	
5/28/81	630	10717.0	4.2	10.3	11	47	11	50	3	27	
5/28/81	645	10717.0	4.2	10.4	10	46	10	49	3	26	
5/28/81	700	10717.0	4.2	10.4	10	45	10	48	3	26	
5/28/81	715	10717.0	3.9	8.5	1	63	1	66	0	35	
5/28/81	730	10717.0	4.2	10.4	4	45	4	48	1	26	
5/28/81	745	10717.0	5.3	9.6	4	52	4	59	1	32	
5/28/81	800	10717.0	4.0	10.5	4	45	4	47	1	25	
5/28/81	815	10717.0	4.5	10.3	4	46	4	50	1	27	
5/28/81	830	10717.0	4.2	10.4	5	46	5	49	1	26	
5/28/81	845	10717.0	4.2	10.4	5	48	5	51	1	27	
5/28/81	900	10717.0	4.4	10.3	4	47	4	50	1	27	
5/28/81	915	10717.0	4.0	10.6	4	45	4	47	1	25	
5/28/81	930	10717.0	4.2	10.4	4	47	4	50	1	27	
5/28/81	945	10717.0	5.3	9.6	4	53	4	60	1	32	
5/28/81	1000	10717.0	4.2	10.5	3	47	3	50	1	27	
5/28/81	1015	10717.0	4.1	10.5	3	47	3	50	1	27	
5/28/81	1030	10717.0	4.2	10.4	3	48	3	51	1	27	
5/28/81	1045	10717.0	4.2	10.4	3	48	3	51	1	27	
5/28/81	1100	10717.0	4.0	10.5	3	48	3	50	1	27	
5/28/81	1115	10717.0	4.0	10.5	3	48	3	50	1	27	
5/28/81	1130	10717.0	4.0	10.5	3	48	3	50	1	27	
5/28/81	1145	10717.0	4.5	10.1	2	60	2	65	0	35	
5/28/81	1200	10717.0	4.0	10.4	3	51	3	54	1	29	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/28/81	1215	10717.0	4.1	10.4	2	51	2	54	0	29	
5/28/81	1230	10717.0	4.0	10.4	3	51	3	54	1	29	
5/28/81	1245	10717.0	4.1	10.3	3	53	3	56	1	30	
5/28/81	1300	10717.0	4.2	10.4	2	50	2	53	0	29	
5/28/81	1315	10717.0	4.1	10.5	2	49	2	52	0	28	
5/28/81	1330	10717.0	4.0	10.5	2	48	2	50	0	27	
5/28/81	1345	10717.0	4.0	10.5	2	48	2	50	0	27	
5/28/81	1400	10717.0	3.9	10.6	2	48	2	50	0	27	
5/28/81	1415	10717.0	3.9	10.6	2	48	2	50	0	27	
5/28/81	1430	10717.0	4.0	10.6	3	48	3	50	1	27	
5/28/81	1445	10717.0	4.0	10.6	2	48	2	50	0	27	
5/28/81	1500	10717.0	4.2	10.5	2	48	2	51	0	27	
5/28/81	1515	10717.0	4.2	10.4	2	48	2	51	0	27	
5/28/81	1530	10717.0	4.0	10.6	3	46	3	48	1	26	
5/28/81	1545	10717.0	4.2	10.3	3	46	3	49	1	26	
5/28/81	1600	10717.0	4.2	10.4	2	48	2	51	0	27	
5/28/81	1615	10717.0	4.0	10.4	3	47	3	49	1	27	
5/28/81	1630	10717.0	4.0	10.5	3	46	3	48	1	26	
5/28/81	1645	10717.0	4.0	10.5	2	46	2	48	0	26	
5/28/81	1700	10717.0	4.1	10.5	3	47	3	50	1	27	
5/28/81	1715	10717.0	4.0	10.5	3	46	3	48	1	26	
5/28/81	1730	10717.0	4.0	10.5	3	47	3	49	1	27	
5/28/81	1745	10717.0	4.0	10.5	3	47	3	49	1	27	
5/28/81	1800	10717.0	4.0	10.5	4	47	4	49	1	27	
5/28/81	1815	10717.0	4.0	10.5	4	47	4	49	1	27	
5/28/81	1830	10717.0	4.0	10.5	1	47	1	49	0	27	
5/28/81	1845	10717.0	4.0	10.5	4	48	4	50	1	27	
5/28/81	1900	10717.0	4.0	10.5	4	47	4	49	1	27	
5/28/81	1915	10717.0	4.0	10.6	4	47	4	49	1	27	
5/28/81	1930	10717.0	4.2	10.4	4	47	4	50	1	27	
5/28/81	1945	10717.0	4.0	10.6	4	46	4	48	1	26	
5/28/81	2000	10717.0	4.1	10.5	4	47	4	50	1	27	
5/28/81	2015	10717.0	4.1	10.5	4	47	4	50	1	27	
5/28/81	2030	10717.0	4.1	10.5	3	47	3	50	1	27	
5/28/81	2045	10717.0	4.1	10.5	3	46	3	49	1	26	
5/28/81	2100	10717.0	4.1	10.5	3	46	3	49	1	26	
5/28/81	2115	10717.0	4.2	10.4	0	46	0	49	0	26	
5/28/81	2130	10717.0	4.2	10.4	0	45	0	48	0	26	
5/28/81	2145	10717.0	4.3	10.4	0	45	0	48	0	26	
5/28/81	2200	10717.0	4.2	10.5	1	43	1	46	0	25	
5/28/81	2215	10717.0	4.0	10.6	3	42	3	44	1	24	
5/28/81	2230	10717.0	3.8	10.8	5	41	5	42	1	23	
5/28/81	2245	10717.0	3.9	10.7	5	42	5	44	1	23	
5/28/81	2300	10717.0	3.7	10.8	5	41	5	42	1	23	
5/28/81	2315	10717.0	3.8	10.8	5	42	5	43	1	23	
5/28/81	2330	10717.0	3.8	10.7	4	43	4	45	1	24	
5/28/81	2345	10717.0	3.9	10.6	4	44	4	46	1	25	
5/28/81	2400	10717.0	3.9	10.7	4	44	4	46	1	25	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/29/81	15	10717.0	3.8	10.7	4	43	4	45	1	24	
5/29/81	30	10717.0	3.9	10.6	5	43	5	45	1	24	
5/29/81	45	10717.0	3.5	10.9	4	41	4	42	1	22	
5/29/81	100	10717.0	3.5	10.8	2	41	2	42	0	22	
5/29/81	115	10717.0	3.7	10.8	1	42	1	43	0	23	
5/29/81	130	10717.0	3.7	10.7	2	42	2	43	0	23	
5/29/81	145	10717.0	3.8	10.8	3	43	3	45	1	24	
5/29/81	200	10717.0	3.9	10.7	2	43	2	45	0	24	
5/29/81	215	10717.0	3.8	10.8	16	43	16	45	5	24	
5/29/81	230	10717.0	3.6	10.9	2	42	2	43	0	23	
5/29/81	245	10717.0	3.9	10.7	1	44	1	46	0	25	
5/29/81	300	10717.0	3.9	10.6	2	44	2	46	0	25	
5/29/81	315	10717.0	3.9	10.6	3	44	3	46	1	25	
5/29/81	330	10717.0	3.9	10.7	2	44	2	46	0	25	
5/29/81	345	10717.0	3.8	10.7	1	43	1	45	0	24	
5/29/81	400	10717.0	3.9	10.7	0	44	0	46	0	25	
5/29/81	415	10717.0	3.9	10.6	0	44	0	46	0	25	
5/29/81	430	10717.0	3.9	10.7	1	44	1	46	0	25	
5/29/81	445	10717.0	3.9	10.7	1	43	1	45	0	24	
5/29/81	500	10717.0	3.9	10.7	0	43	0	45	0	24	
5/29/81	515	10717.0	4.0	10.6	-1	43	-1	45	0	24	
5/29/81	530	10717.0	4.0	10.6	-1	44	-1	46	0	25	
5/29/81	545	10717.0	4.0	10.5	1	43	1	45	0	24	
5/29/81	600	10717.0	4.0	10.6	0	44	0	46	0	25	
5/29/81	615	10717.0	3.9	10.6	1	43	1	45	0	24	
5/29/81	630	10717.0	4.0	10.7	1	44	1	46	0	25	
5/29/81	645	10717.0	4.0	10.7	1	44	1	46	0	25	
5/29/81	700	10717.0	4.0	10.6	2	44	2	46	0	25	
5/29/81	715	10717.0	4.0	10.6	2	44	2	46	0	25	
5/29/81	730	10717.0	4.0	10.6	1	45	1	47	0	25	
5/29/81	745	10717.0	4.0	10.6	1	44	1	46	0	25	
5/29/81	800	10717.0	3.9	10.7	1	44	1	46	0	25	
5/29/81	815	10717.0	3.7	10.8	0	43	0	44	0	24	
5/29/81	830	10717.0	3.5	9.7	61	50	62	51	20	27	
5/29/81	845	10717.0	4.0	10.6	10	53	10	56	3	30	
5/29/81	900	10717.0	4.0	10.5	8	53	8	56	2	30	
5/29/81	915	10717.0	3.8	10.7	8	52	8	54	2	29	
5/29/81	930	10717.0	4.0	10.5	8	53	8	56	2	30	
5/29/81	945	10717.0	4.0	10.5	9	54	9	57	3	31	
5/29/81	1000	10717.0	4.0	10.5	9	54	9	57	3	31	
5/29/81	1015	10717.0	4.0	10.5	8	54	8	57	2	31	
5/29/81	1030	10717.0	3.9	10.6	9	54	9	56	3	30	
5/29/81	1045	10717.0	4.0	10.5	10	55	10	58	3	31	
5/29/81	1100	10717.0	4.0	10.6	10	58	10	61	3	33	
5/29/81	1115	10717.0	3.9	10.8	10	56	10	58	3	31	
5/29/81	1130	10717.0	4.0	10.7	8	57	8	60	2	32	
5/29/81	1145	10717.0	3.9	10.8	8	56	8	58	2	31	
5/29/81	1200	10717.0	3.9	10.8	7	56	7	58	2	31	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/29/81	1215	10717.0	3.9	10.8	7	56	7	58	2	31	
5/29/81	1230	10717.0	3.9	10.8	7	56	7	58	2	31	
5/29/81	1245	10717.0	3.8	10.9	8	56	8	58	2	31	
5/29/81	1300	10717.0	3.7	10.9	15	56	15	58	5	31	
5/29/81	1315	10717.0	3.8	10.9	15	57	15	59	5	32	
5/29/81	1330	10717.0	3.9	10.8	15	57	15	60	5	32	
5/29/81	1345	10717.0	3.8	10.9	18	57	18	59	6	32	
5/29/81	1400	10717.0	3.8	10.9	16	57	16	59	5	32	
5/29/81	1415	10717.0	3.8	10.9	15	57	15	59	5	32	
5/29/81	1430	10717.0	3.9	10.8	16	58	16	61	5	33	
5/29/81	1445	10717.0	3.8	10.9	16	57	16	59	5	32	
5/29/81	1500	10717.0	3.9	10.8	18	58	18	61	6	33	
5/29/81	1515	10717.0	3.8	10.9	16	57	16	59	5	32	
5/29/81	1530	10717.0	3.8	10.9	15	57	15	59	5	32	
5/29/81	1545	10717.0	3.7	10.9	15	56	15	58	5	31	
5/29/81	1600	10717.0	3.7	10.9	16	57	16	59	5	32	
5/29/81	1615	10717.0	3.7	10.9	14	56	14	58	4	31	
5/29/81	1630	10717.0	3.7	10.9	15	56	15	58	5	31	
5/29/81	1645	10717.0	3.6	11.0	14	55	14	56	4	30	
5/29/81	1700	10717.0	3.7	10.9	14	57	14	59	4	32	
5/29/81	1715	10717.0	3.6	11.0	16	56	16	57	5	31	
5/29/81	1730	10717.0	3.6	10.9	15	56	15	57	5	31	
5/29/81	1745	10717.0	3.6	11.0	15	56	15	57	5	31	
5/29/81	1800	10717.0	3.6	10.9	17	56	17	57	5	31	
5/29/81	1815	10717.0	3.6	11.0	16	56	16	57	5	31	
5/29/81	1830	10717.0	3.5	11.0	15	56	15	57	5	31	
5/29/81	1845	10717.0	3.6	10.9	15	57	15	58	5	31	
5/29/81	1900	10717.0	3.6	11.0	14	57	14	58	4	31	
5/29/81	1915	10717.0	3.7	10.8	13	58	13	60	4	32	
5/29/81	1930	10717.0	3.6	10.9	13	58	13	60	4	32	
5/29/81	1945	10717.0	3.8	10.8	14	59	14	61	4	33	
5/29/81	2000	10717.0	3.7	10.9	14	58	14	60	4	32	
5/29/81	2015	10717.0	3.7	10.9	13	58	13	60	4	32	
5/29/81	2030	10717.0	3.7	10.9	14	58	14	60	4	32	
5/29/81	2045	10717.0	3.8	10.9	20	58	20	60	6	32	
5/29/81	2100	10717.0	3.8	11.8	13	58	13	60	4	32	
5/29/81	2115	10717.0	3.8	10.8	12	57	12	59	4	32	
5/29/81	2130	10717.0	3.8	10.8	12	57	12	59	4	32	
5/29/81	2145	10717.0	3.8	10.8	13	56	13	58	4	31	
5/29/81	2200	10717.0	3.9	10.8	13	56	13	58	4	31	
5/29/81	2215	10717.0	3.9	10.8	13	55	13	57	4	31	
5/29/81	2230	10717.0	3.8	10.9	15	53	15	55	5	30	
5/29/81	2245	10717.0	3.9	10.7	13	54	13	56	4	30	
5/29/81	2300	10717.0	3.8	10.8	16	52	16	54	5	29	
5/29/81	2315	10717.0	3.9	10.8	18	51	18	53	6	29	
5/29/81	2330	10717.0	3.9	10.8	18	52	18	54	6	29	
5/29/81	2345	10717.0	3.9	10.7	16	51	16	53	5	29	
5/29/81	2400	10717.0	3.9	10.8	14	50	14	52	4	28	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/30/81	15	10717.0	4.0	10.7	15	50	15	52	5	28	
5/30/81	30	10717.0	4.0	10.6	13	51	13	54	4	29	
5/30/81	45	10717.0	4.2	10.4	13	53	13	56	4	30	
5/30/81	100	10717.0	4.0	10.5	14	53	14	56	4	30	
5/30/81	115	10717.0	4.0	10.5	13	53	13	56	4	30	
5/30/81	130	10717.0	3.8	10.7	12	52	12	54	4	29	
5/30/81	145	10717.0	4.0	10.7	18	54	19	57	6	31	
5/30/81	200	10717.0	4.3	10.4	16	56	17	60	5	32	
5/30/81	215	10717.0	4.2	10.4	15	56	16	60	5	32	
5/30/81	230	10717.0	4.1	10.4	14	54	14	57	4	31	
5/30/81	245	10717.0	4.2	10.5	14	55	15	58	4	31	
5/30/81	300	10717.0	4.2	10.4	14	55	15	58	4	31	
5/30/81	315	10717.0	4.2	10.5	14	54	15	57	4	31	
5/30/81	330	10717.0	4.2	10.4	14	54	15	57	4	31	
5/30/81	345	10717.0	4.2	10.5	15	54	16	57	5	31	
5/30/81	400	10717.0	4.2	10.4	14	55	15	58	4	31	
5/30/81	415	10717.0	4.3	10.4	13	56	14	60	4	32	
5/30/81	430	10717.0	4.2	10.4	13	57	13	61	4	33	
5/30/81	445	10717.0	4.2	10.4	11	56	11	60	3	32	
5/30/81	500	10717.0	4.1	10.5	15	56	15	59	5	32	
5/30/81	515	10717.0	4.2	10.4	13	56	13	60	4	32	
5/30/81	530	10717.0	4.3	10.3	12	57	12	61	4	33	
5/30/81	545	10717.0	4.2	10.4	14	57	15	61	4	33	
5/30/81	600	10717.0	4.3	10.4	16	57	17	61	5	33	
5/30/81	615	10717.0	4.5	10.3	15	57	16	62	5	33	
5/30/81	630	10717.0	4.4	10.3	12	57	13	61	4	33	
5/30/81	645	10717.0	4.3	10.4	12	56	12	60	4	32	
5/30/81	700	10717.0	4.2	10.5	21	54	22	57	7	31	
5/30/81	715	10717.0	4.1	10.5	25	55	26	58	8	31	
5/30/81	730	10717.0	4.1	10.5	19	54	20	57	6	31	
5/30/81	745	10717.0	4.2	10.6	13	53	13	56	4	30	
5/30/81	800	10717.0	4.3	10.6	12	56	12	60	4	32	
5/30/81	815	10717.0	3.8	10.9	12	50	12	52	4	28	
5/30/81	830	10717.0	4.0	10.8	12	52	12	55	4	29	
5/30/81	845	10717.0	4.1	10.7	13	51	13	54	4	29	
5/30/81	900	10717.0	3.7	10.9	16	52	16	54	5	29	
5/30/81	915	10717.0	4.1	10.7	15	55	15	58	5	31	
5/30/81	930	10717.0	4.0	10.8	13	53	13	56	4	30	
5/30/81	945	10717.0	4.2	10.6	13	54	13	57	4	31	
5/30/81	1000	10717.0	4.1	10.7	16	47	17	50	5	27	
5/30/81	1015	10717.0	3.8	10.9	14	49	14	51	4	27	
5/30/81	1030	10717.0	3.9	10.9	13	48	13	50	4	27	
5/30/81	1045	10717.0	3.7	10.9	13	48	13	49	4	27	
5/30/81	1100	10717.0	4.0	10.8	12	49	12	51	4	28	
5/30/81	1115	10717.0	3.8	10.9	12	47	12	49	4	26	
5/30/81	1130	10717.0	3.9	10.9	11	49	11	51	3	27	
5/30/81	1145	10717.0	4.0	10.8	14	50	14	52	4	28	
5/30/81	1200	10717.0	3.8	10.9	16	51	16	53	5	28	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/30/81	1215	10717.0	3.7	10.9	14	50	14	52	4	28	
5/30/81	1230	10717.0	3.9	10.9	14	52	14	54	4	29	
5/30/81	1245	10717.0	3.8	10.9	13	49	13	51	4	27	
5/30/81	1300	10717.0	3.7	10.9	14	47	14	48	4	26	
5/30/81	1315	10717.0	3.7	10.9	15	48	15	49	5	27	
5/30/81	1330	10717.0	4.0	10.8	15	50	15	52	5	28	
5/30/81	1345	10717.0	3.5	11.1	12	46	12	47	4	25	
5/30/81	1400	10717.0	3.9	10.9	12	48	12	50	4	27	
5/30/81	1415	10717.0	3.6	11.0	11	46	11	47	3	25	
5/30/81	1430	10717.0	3.9	10.9	14	47	14	49	4	26	
5/30/81	1445	10717.0	4.0	10.8	14	50	14	52	4	28	
5/30/81	1500	10717.0	3.6	11.0	13	46	13	47	4	25	
5/30/81	1515	10717.0	3.5	11.1	14	47	14	48	4	26	
5/30/81	1530	10717.0	3.5	11.1	14	48	14	49	4	26	
5/30/81	1545	10717.0	3.3	11.2	11	47	11	47	3	25	
5/30/81	1600	10717.0	3.6	11.0	12	48	12	49	4	26	
5/30/81	1615	10717.0	3.7	10.9	11	47	11	48	3	26	
5/30/81	1630	10717.0	3.7	10.9	11	48	11	49	3	27	
5/30/81	1645	10717.0	3.6	11.0	14	47	14	48	4	26	
5/30/81	1700	10717.0	3.7	10.9	14	49	14	50	4	27	
5/30/81	1715	10717.0	3.8	10.9	12	48	12	50	4	27	
5/30/81	1730	10717.0	3.8	10.9	12	49	12	51	4	27	
5/30/81	1745	10717.0	3.5	11.1	15	45	15	46	5	25	
5/30/81	1800	10717.0	3.5	11.1	16	46	16	47	5	25	
5/30/81	1815	10717.0	3.5	11.1	15	43	15	44	5	23	
5/30/81	1830	10717.0	3.6	11.0	13	44	13	45	4	24	
5/30/81	1845	10717.0	3.7	10.9	12	42	12	43	4	23	
5/30/81	1900	10717.0	3.6	11.0	15	44	15	45	5	24	
5/30/81	1915	10717.0	3.7	10.9	14	43	14	44	4	24	
5/30/81	1930	10717.0	3.6	11.0	12	42	12	43	4	23	
5/30/81	1945	10717.0	3.6	11.0	12	44	12	45	4	24	
5/30/81	2000	10717.0	3.5	11.1	16	44	16	45	5	24	
5/30/81	2015	10717.0	3.4	11.2	16	45	16	46	5	24	
5/30/81	2030	10717.0	3.4	11.2	18	43	18	43	6	23	
5/30/81	2045	10717.0	3.6	11.0	13	42	13	43	4	23	
5/30/81	2100	10717.0	3.7	10.9	13	43	13	44	4	24	
5/30/81	2115	10717.0	3.7	10.9	14	44	14	45	4	24	
5/30/81	2130	10717.0	3.8	10.9	12	45	12	47	4	25	
5/30/81	2145	10717.0	3.7	10.9	13	46	13	47	4	25	
5/30/81	2200	10717.0	3.7	10.9	13	47	13	48	4	26	
5/30/81	2215	10717.0	3.6	11.0	15	46	15	47	5	25	
5/30/81	2230	10717.0	3.7	10.9	13	46	13	47	4	25	
5/30/81	2245	10717.0	3.5	11.1	18	45	18	46	6	25	
5/30/81	2300	10717.0	3.6	11.0	14	44	14	45	4	24	
5/30/81	2315	10717.0	3.5	11.1	16	44	16	45	5	24	
5/30/81	2330	10717.0	3.7	10.9	13	43	13	44	4	24	
5/30/81	2345	10717.0	3.6	11.1	13	42	13	43	4	23	
5/30/81	2400	10717.0	3.5	11.1	17	42	17	43	5	23	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/31/81	15	10717.0	3.7	10.9	11	45	11	46	3	25	
5/31/81	30	10717.0	3.8	10.9	14	45	14	47	4	25	
5/31/81	45	10717.0	3.8	10.9	13	45	13	47	4	25	
5/31/81	100	10717.0	3.7	10.9	15	46	15	47	5	25	
5/31/81	115	10717.0	3.8	10.9	13	46	13	48	4	26	
5/31/81	130	10717.0	3.8	10.9	11	46	11	48	3	26	
5/31/81	145	10717.0	3.7	10.9	10	45	10	46	3	25	
5/31/81	200	10717.0	3.7	10.9	11	46	11	47	3	25	
5/31/81	215	10717.0	3.8	10.9	9	46	9	48	3	26	
5/31/81	230	10717.0	3.9	10.9	12	46	12	48	4	26	
5/31/81	245	10717.0	4.0	10.8	11	48	11	50	3	27	
5/31/81	300	10717.0	4.0	10.8	10	47	10	49	3	27	
5/31/81	315	10717.0	4.0	10.8	13	48	13	50	4	27	
5/31/81	330	10717.0	3.7	10.9	12	47	12	48	4	26	
5/31/81	345	10717.0	3.7	10.9	11	47	11	48	3	26	
5/31/81	400	10717.0	4.0	10.9	14	48	14	50	4	27	
5/31/81	415	10717.0	4.0	10.8	15	47	15	49	5	27	
5/31/81	430	10717.0	4.0	10.8	14	47	14	49	4	27	
5/31/81	445	10717.0	3.9	10.9	14	47	14	49	4	26	
5/31/81	500	10717.0	3.9	10.9	14	47	14	49	4	26	
5/31/81	515	10717.0	3.9	10.9	11	47	11	49	3	26	
5/31/81	530	10717.0	4.0	10.8	12	47	12	49	4	27	
5/31/81	545	10717.0	4.1	10.7	12	47	12	50	4	27	
5/31/81	600	10717.0	4.0	10.8	12	47	12	49	4	27	
5/31/81	615	10717.0	3.9	10.9	15	47	15	49	5	26	
5/31/81	630	10717.0	3.9	10.9	14	47	14	49	4	26	
5/31/81	645	10717.0	3.9	10.9	8	48	8	50	2	27	
5/31/81	700	10717.0	3.9	10.9	11	49	11	51	3	27	
5/31/81	715	10717.0	3.9	10.9	11	49	11	51	3	27	
5/31/81	730	10717.0	3.8	9.6	13	51	13	53	4	28	
5/31/81	745	10717.0	4.1	10.7	10	46	10	49	3	26	
5/31/81	800	10717.0	4.1	10.7	10	46	10	49	3	26	
5/31/81	815	10717.0	4.2	10.6	10	47	10	50	3	27	
5/31/81	830	10717.0	4.2	10.6	10	47	10	50	3	27	
5/31/81	845	10717.0	4.1	10.7	10	47	10	50	3	27	
5/31/81	900	10717.0	4.1	10.7	10	46	10	49	3	26	
5/31/81	915	10717.0	4.4	10.5	10	47	10	50	3	27	
5/31/81	930	10717.0	4.1	10.7	10	46	10	49	3	26	
5/31/81	945	10717.0	4.0	10.7	10	45	10	47	3	25	
5/31/81	1000	10717.0	3.9	10.8	9	45	9	47	3	25	
5/31/81	1015	10717.0	4.0	10.7	9	45	9	47	3	25	
5/31/81	1030	10717.0	3.9	10.8	9	44	9	46	3	25	
5/31/81	1045	10717.0	4.0	10.8	9	45	9	47	3	25	
5/31/81	1100	10717.0	4.0	10.7	9	45	9	47	3	25	
5/31/81	1115	10717.0	4.0	10.7	9	45	9	47	3	25	
5/31/81	1130	10717.0	3.7	10.9	10	44	10	45	3	24	
5/31/81	1145	10717.0	3.8	10.9	11	45	11	47	3	25	
5/31/81	1200	10717.0	3.9	10.9	11	47	11	49	3	26	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL

15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
5/31/81	1215	10717.0	3.9	10.8	12	47	12	49	4	26	
5/31/81	1230	10717.0	3.8	10.9	12	46	12	48	4	26	
5/31/81	1245	10717.0	4.0	10.8	11	48	11	50	3	27	
5/31/81	1300	10717.0	3.9	10.9	11	47	11	49	3	26	
5/31/81	1315	10717.0	3.8	10.9	11	46	11	48	3	26	
5/31/81	1330	10717.0	3.9	10.7	10	46	10	48	3	26	
5/31/81	1345	10717.0	3.9	10.8	11	47	11	49	3	26	
5/31/81	1400	10717.0	3.8	10.9	12	46	12	48	4	26	
5/31/81	1415	10717.0	3.6	11.0	12	44	12	45	4	24	
5/31/81	1430	10717.0	3.8	10.9	12	45	12	47	4	25	
5/31/81	1445	10717.0	3.7	10.9	13	44	13	45	4	24	
5/31/81	1500	10717.0	3.7	10.9	12	44	12	45	4	24	
5/31/81	1515	10717.0	3.9	10.7	12	45	12	47	4	25	
5/31/81	1530	10717.0	3.7	10.9	12	44	12	45	4	24	
5/31/81	1545	10717.0	3.7	10.9	12	44	12	45	4	24	
5/31/81	1600	10717.0	3.7	10.9	12	44	12	45	4	24	
5/31/81	1615	10717.0	3.7	10.9	12	45	12	46	4	25	
5/31/81	1630	10717.0	3.8	10.8	12	45	12	47	4	25	
5/31/81	1645	10717.0	3.8	10.8	12	45	12	47	4	25	
5/31/81	1700	10717.0	3.7	10.9	13	45	13	46	4	25	
5/31/81	1715	10717.0	3.7	10.9	13	45	13	46	4	25	
5/31/81	1730	10717.0	3.8	10.8	13	45	13	47	4	25	
5/31/81	1745	10717.0	3.6	10.9	13	43	13	44	4	24	
5/31/81	1800	10717.0	3.6	11.0	14	44	14	45	4	24	
5/31/81	1815	10717.0	3.6	10.9	14	43	14	44	4	24	
5/31/81	1830	10717.0	3.6	10.9	15	44	15	45	5	24	
5/31/81	1845	10717.0	3.7	10.9	15	44	15	45	5	24	
5/31/81	1900	10717.0	3.7	10.9	15	44	15	45	5	24	
5/31/81	1915	10717.0	3.4	11.0	15	42	15	42	5	23	
5/31/81	1930	10717.0	3.6	10.9	16	44	16	45	5	24	
5/31/81	1945	10717.0	3.5	11.0	16	43	16	44	5	23	
5/31/81	2000	10717.0	3.6	10.9	15	44	15	45	5	24	
5/31/81	2015	10717.0	3.7	10.9	16	45	16	46	5	25	
5/31/81	2030	10717.0	3.9	10.8	15	46	15	48	5	26	
5/31/81	2045	10717.0	3.9	10.7	15	46	15	48	5	26	
5/31/81	2100	10717.0	4.0	10.7	14	46	14	48	4	26	
5/31/81	2115	10717.0	4.0	10.7	12	46	12	48	4	26	
5/31/81	2130	10717.0	3.9	10.8	12	46	12	48	4	26	
5/31/81	2145	10717.0	4.0	10.7	12	46	12	48	4	26	
5/31/81	2200	10717.0	3.9	10.8	13	45	13	47	4	25	
5/31/81	2215	10717.0	4.0	10.8	13	46	13	48	4	26	
5/31/81	2230	10717.0	4.0	10.7	14	46	14	48	4	26	
5/31/81	2245	10717.0	4.0	10.7	14	46	14	48	4	26	
5/31/81	2300	10717.0	4.0	10.7	14	46	14	48	4	26	
5/31/81	2315	10717.0	4.0	10.7	14	47	14	49	4	27	
5/31/81	2330	10717.0	4.0	10.7	13	46	13	48	4	26	
5/31/81	2345	10717.0	4.0	10.7	13	46	13	48	4	26	
5/31/81	2400	10717.0	4.0	10.7	14	45	14	47	4	25	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
6/ 1/81	15	10717.0	3.9	10.8	14	45	14	47	4	25	
6/ 1/81	30	10717.0	4.0	10.8	13	45	13	47	4	25	
6/ 1/81	45	10717.0	3.9	10.8	15	45	15	47	5	25	
6/ 1/81	100	10717.0	4.0	10.7	16	45	16	47	5	25	
6/ 1/81	115	10717.0	4.0	10.7	16	45	16	47	5	25	
6/ 1/81	130	10717.0	4.1	10.7	17	45	18	47	5	26	
6/ 1/81	145	10717.0	4.1	10.7	17	46	18	49	5	26	
6/ 1/81	200	10717.0	4.0	10.7	17	45	18	47	5	25	
6/ 1/81	215	10717.0	4.0	10.7	15	45	15	47	5	25	
6/ 1/81	230	10717.0	4.0	10.7	14	45	14	47	4	25	
6/ 1/81	245	10717.0	4.0	10.7	16	45	16	47	5	25	
6/ 1/81	300	10717.0	4.0	10.7	17	46	18	48	5	26	
6/ 1/81	315	10717.0	4.1	10.7	17	46	18	49	5	26	
6/ 1/81	330	10717.0	4.0	10.7	18	46	19	48	6	26	
6/ 1/81	345	10717.0	4.0	10.7	18	46	19	48	6	26	
6/ 1/81	400	10717.0	4.0	10.7	18	45	19	47	6	25	
6/ 1/81	415	10717.0	4.0	10.7	17	45	18	47	5	25	
6/ 1/81	430	10717.0	4.0	10.7	17	45	18	47	5	25	
6/ 1/81	445	10717.0	4.0	10.7	17	45	18	47	5	25	
6/ 1/81	500	10717.0	4.0	10.8	17	45	18	47	5	25	
6/ 1/81	515	10717.0	4.0	10.7	18	44	19	46	6	25	
6/ 1/81	530	10717.0	4.0	10.7	18	43	19	45	6	24	
6/ 1/81	545	10717.0	4.1	10.7	18	44	19	46	6	25	
6/ 1/81	600	10717.0	4.0	10.7	19	44	20	46	6	25	
6/ 1/81	615	10717.0	4.0	10.7	19	44	20	46	6	25	
6/ 1/81	630	10717.0	4.0	10.7	19	45	20	47	6	25	
6/ 1/81	645	10717.0	3.9	10.8	19	45	20	47	6	25	
6/ 1/81	700	10717.0	3.8	10.9	19	44	19	46	6	24	
6/ 1/81	715	10717.0	3.9	10.8	19	45	20	47	6	25	
6/ 1/81	730	10717.0	4.2	10.7	19	46	20	49	6	26	
6/ 1/81	745	10717.0	.0	.0	0	0	0	0	0	0	C
6/ 1/81	800	10717.0	.0	.0	0	0	0	0	0	0	C
6/ 1/81	815	10717.0	4.2	10.4	5	47	5	50	1	27	
6/ 1/81	830	10717.0	3.9	10.5	5	46	5	48	1	26	
6/ 1/81	845	10717.0	3.2	11.0	0	40	0	40	0	21	
6/ 1/81	900	10717.0	4.3	10.4	5	47	5	50	1	27	
6/ 1/81	915	10717.0	4.0	10.6	5	46	5	48	1	26	
6/ 1/81	930	10717.0	3.8	10.6	5	45	5	47	1	25	
6/ 1/81	945	10717.0	3.9	10.6	5	46	5	48	1	26	
6/ 1/81	1000	10717.0	3.9	10.6	5	46	5	48	1	26	
6/ 1/81	1015	10717.0	3.8	10.6	5	46	5	48	1	26	
6/ 1/81	1030	10717.0	3.9	10.6	5	47	5	49	1	26	
6/ 1/81	1045	10717.0	3.8	10.6	5	47	5	49	1	26	
6/ 1/81	1100	10717.0	3.8	10.6	5	47	5	49	1	26	
6/ 1/81	1115	10717.0	3.8	10.6	5	47	5	49	1	26	
6/ 1/81	1130	10717.0	3.7	10.7	5	47	5	48	1	26	
6/ 1/81	1145	10717.0	3.7	10.7	4	48	4	49	1	27	
6/ 1/81	1200	10717.0	3.8	10.7	4	48	4	50	1	27	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN. DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
6/ 1/81	1215	10717.0	3.7	10.7	4	48	4	49	1	27	
6/ 1/81	1230	10717.0	3.6	10.8	5	48	5	49	1	26	
6/ 1/81	1245	10717.0	3.6	10.8	5	48	5	49	1	26	
6/ 1/81	1300	10717.0	3.5	10.8	4	47	4	48	1	26	
6/ 1/81	1315	10717.0	3.5	10.8	4	47	4	48	1	26	
6/ 1/81	1330	10717.0	3.7	10.7	4	48	4	49	1	27	
6/ 1/81	1345	10717.0	3.5	10.8	4	46	4	47	1	25	
6/ 1/81	1400	10717.0	3.7	10.7	4	47	4	48	1	26	
6/ 1/81	1415	10717.0	3.6	10.8	3	48	3	49	1	26	
6/ 1/81	1430	10717.0	3.5	10.8	4	47	4	48	1	26	
6/ 1/81	1445	10717.0	3.5	10.8	4	47	4	48	1	26	
6/ 1/81	1500	10717.0	3.5	10.8	4	47	4	48	1	26	
6/ 1/81	1515	10717.0	3.6	10.8	4	47	4	48	1	26	
6/ 1/81	1530	10717.0	3.6	10.8	4	47	4	48	1	26	
6/ 1/81	1545	10717.0	3.7	10.8	4	48	4	49	1	27	
6/ 1/81	1600	10717.0	3.6	10.8	4	48	4	49	1	26	
6/ 1/81	1615	10717.0	3.6	10.8	4	48	4	49	1	26	
6/ 1/81	1630	10717.0	3.4	10.9	4	47	4	48	1	26	
6/ 1/81	1645	10717.0	3.5	10.9	4	46	4	47	1	25	
6/ 1/81	1700	10717.0	3.4	10.9	3	46	3	47	1	25	
6/ 1/81	1715	10717.0	3.4	10.9	3	46	3	47	1	25	
6/ 1/81	1730	10717.0	3.4	10.9	3	46	3	47	1	25	
6/ 1/81	1745	10717.0	3.4	10.9	3	47	3	48	1	26	
6/ 1/81	1800	10717.0	3.5	10.9	3	47	3	48	1	26	
6/ 1/81	1815	10717.0	3.4	10.9	3	46	3	47	1	25	
6/ 1/81	1830	10717.0	3.5	10.8	4	48	4	49	1	26	
6/ 1/81	1845	10717.0	3.6	10.8	3	48	3	49	1	26	
6/ 1/81	1900	10717.0	3.4	10.9	4	47	4	48	1	26	
6/ 1/81	1915	10717.0	3.4	10.9	4	47	4	48	1	26	
6/ 1/81	1930	10717.0	3.5	10.9	4	47	4	48	1	26	
6/ 1/81	1945	10717.0	3.4	10.9	4	46	4	47	1	25	
6/ 1/81	2000	10717.0	3.1	11.0	4	45	4	45	1	24	
6/ 1/81	2015	10717.0	3.3	11.0	4	45	4	45	1	24	
6/ 1/81	2030	10717.0	3.5	10.8	4	46	4	47	1	25	
6/ 1/81	2045	10717.0	3.4	10.9	4	45	4	46	1	24	
6/ 1/81	2100	10717.0	3.6	10.8	4	45	4	46	1	25	
6/ 1/81	2115	10717.0	3.4	10.9	4	44	4	45	1	24	
6/ 1/81	2130	10717.0	3.4	11.0	5	44	5	45	1	24	
6/ 1/81	2145	10717.0	3.5	10.9	5	44	5	45	1	24	
6/ 1/81	2200	10717.0	3.5	10.9	4	44	4	45	1	24	
6/ 1/81	2215	10717.0	3.7	10.8	3	44	3	45	1	24	
6/ 1/81	2230	10717.0	3.8	10.7	4	45	4	47	1	25	
6/ 1/81	2245	10717.0	3.8	10.7	4	45	4	47	1	25	
6/ 1/81	2300	10717.0	3.7	10.8	5	44	5	45	1	24	
6/ 1/81	2315	10717.0	3.7	10.8	5	43	5	44	1	24	
6/ 1/81	2330	10717.0	3.7	10.8	5	43	5	44	1	24	
6/ 1/81	2345	10717.0	3.8	10.7	5	44	5	46	1	24	
6/ 1/81	2400	10717.0	3.7	10.8	5	44	5	45	1	24	

PETROLEUM PROCESS HEATER, STAGED COMBUSTION AIR, REFINERY GAS FUEL
15 MIN, DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD B/D	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J	ACODE
6/ 2/81	15	10717.0	3.6	10.9	6	43	6	44	2	24	
6/ 2/81	30	10717.0	3.6	10.8	6	44	6	45	2	24	
6/ 2/81	45	10717.0	3.6	10.8	5	44	5	45	1	24	
6/ 2/81	100	10717.0	3.5	10.9	5	44	5	45	1	24	
6/ 2/81	115	10717.0	3.9	10.8	5	46	5	48	1	26	
6/ 2/81	130	10717.0	3.8	10.7	6	46	6	48	2	26	
6/ 2/81	145	10717.0	3.8	10.7	7	46	7	48	2	26	
6/ 2/81	200	10717.0	4.1	10.5	7	48	7	51	2	27	
6/ 2/81	215	10717.0	4.1	10.5	6	47	6	50	2	27	
6/ 2/81	230	10717.0	4.1	10.6	6	47	6	50	2	27	
6/ 2/81	245	10717.0	4.1	10.5	5	48	5	51	1	27	
6/ 2/81	300	10717.0	4.0	10.6	5	47	5	49	1	27	
6/ 2/81	315	10717.0	4.1	10.5	5	47	5	50	1	27	
6/ 2/81	330	10717.0	4.1	10.5	5	47	5	50	1	27	
6/ 2/81	345	10717.0	4.0	10.6	6	47	6	49	2	27	
6/ 2/81	400	10717.0	4.0	10.6	5	47	5	49	1	27	
6/ 2/81	415	10717.0	4.0	10.6	6	47	6	49	2	27	
6/ 2/81	430	10717.0	3.8	10.7	6	46	6	48	2	26	
6/ 2/81	445	10717.0	3.9	10.7	6	47	6	49	2	26	
6/ 2/81	500	10717.0	3.8	10.7	6	46	6	48	2	26	
6/ 2/81	515	10717.0	3.9	10.7	5	47	5	49	1	26	
6/ 2/81	530	10717.0	3.9	10.7	5	47	5	49	1	26	
6/ 2/81	545	10717.0	4.0	10.7	7	47	7	49	2	27	
6/ 2/81	600	10717.0	3.9	10.6	7	47	7	49	2	26	
6/ 2/81	615	10717.0	3.9	10.7	7	47	7	49	2	26	
6/ 2/81	630	10717.0	4.1	10.5	6	48	6	51	2	27	
6/ 2/81	645	10717.0	4.2	10.5	6	48	6	51	2	27	
6/ 2/81	700	10717.0	4.2	10.5	6	48	6	51	2	27	
6/ 2/81	715	10717.0	4.3	10.5	6	48	6	51	2	28	
6/ 2/81	730	10717.0	4.0	10.6	6	46	6	48	2	26	
6/ 2/81	745	10717.0	3.9	10.6	5	46	5	48	1	26	
6/ 2/81	800	10717.0	3.9	10.6	5	45	5	47	1	25	
6/ 2/81	815	10717.0	.0	.0	0	0	0	0	0	0	C
6/ 2/81	830	10717.0	.0	.0	0	0	0	0	0	0	C
6/ 2/81	845	10717.0	3.9	10.7	8	43	8	45	2	24	
6/ 2/81	900	10717.0	3.9	10.7	9	44	9	46	3	25	
6/ 2/81	915	10717.0	3.9	10.7	8	45	8	47	2	25	
6/ 2/81	930	10717.0	3.9	10.7	8	45	8	47	2	25	
6/ 2/81	945	10717.0	3.9	10.7	8	45	8	47	2	25	
6/ 2/81	1000	10717.0	3.8	10.8	8	44	8	46	2	24	
6/ 2/81	1015	10717.0	3.8	10.7	9	43	9	45	3	24	
6/ 2/81	1030	10717.0	3.7	10.8	9	43	9	44	3	24	
6/ 2/81	1045	10717.0	.0	.0	0	0	0	0	0	0	B
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	
0/ 0/ 0	0	.0	.0	.0	0	0	0	0	0	0	

APPENDIX E

FUEL ANALYSIS REPORTS

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TABLE E-1. GAS ANALYSES FOR 1980 TESTS

	Southern California Natural Gas	Ref. Gas A ~~No~~ 1 ~~Fuel~~ ~~Gas Drum~~ ("Fuel Gas")	Ref. Gas B ("Adsorber Gas") ~~To~~ ~~11 # 13~~
Sample Date	6/13/80	6/17/80	6/26/80
Sample Time	8:30 AM	8:15 AM	8:30 AM
Percent	Gas Vol.	Gas Vol.	Gas Vol.
Hydrogen		20.2	13.6
Nitrogen + Inerts			
Oxygen	0.1		
Carbon ~~Carong~~ Monoxide	1.0	0.6	0.8
Carbon Dioxide	0.9	1.1	
Hydrogen Sulfide		0.5	
Methane	88.5	48.0	32.5
Ethane	7.6	12.1	17.6
Ethylene		4.0	5.8
Propane	1.7	7.1	21.4
Propylene		2.6	3.5
Isobutane	0.1	1.4	3.0
Normal Butane	0.1	0.9	0.4
Total Butenes		0.7	0.5
1, e-Butadiene			
Isopentane	Trace	0.3	0.2
Normal Pentane	Trace	0.1	0.1
Total Pentenes		0.3	0.4
Total C_6 Plus		0.1	0.2

TABLE E-2. TYPICAL NO. 6 FUEL OIL ANALYSES

	1980 Tests	1981 Tests
Carbon, %	87.14	87.28
Hydrogen, %	10.76	10.54
Ash, %	None	0.012
Nitrogen, %	0.76	0.88
Sulfur, %	0.77	0.90
Chlorine, %	0.04	----
Oxygen, % By Diff.	0.53	0.39
HHV (BTU/lb)	20,357	18,320
API Gravity at 60°F	11.0	----

TABLE E-3. ADSORBER GAS ANALYSES FOR SECOND SET OF PARAMETRIC TESTS (1981)

GAS ANALYSIS REPORT

LABORATORY		OPERATOR			DATE	
GAS LAB		D. SPRAGUE			MARCH 30, 1981	
UNIT CRUDE UNIT	ADSORBER [illegible] GAS TO BH13					
SAMPLE DATE	3-30-81					
SAMPLE TIME	8:30 AM					
PERCENT	GAS VOL.					
HYDROGEN 13	14.2					
NITROGEN 9	0.7					
OXYGEN						
CARBON MONOXIDE 17	0.6					
CARBON DIOXIDE 21	0.2					
HYDROGEN SULFIDE 25						
METHANE 29	33.2					
ETHANE 33	17.8					
ETHYLENE 37	5.9					
PROPANE 41	17.2					
PROPYLENE 45	3.5					
ISOBUTANE 49	5.0					
NORMAL BUTANE 53	0.6					
TOTAL BUTENES 57	0.5					
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.1					
NORMAL PENTANE 69	0.1					
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.4					
BTU/CU. FT.	1532					
SPECIFIC GRAVITY	0.9047					

DIST.	REMARKS	PREPARED BY / SUBMITTED BY
GDD(2) JAK RWT		PREPARED BY D Sprague SUBMITTED BY R. G. Wigman

TABLE E-3. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB		OPERATOR: D. SPRAGUE			DATE MARCH 31, 1981	
UNIT CRUDE	ADSORBER ~~FUEL~~ GAS TO 11H13					
SAMPLE DATE	3-31-81					
SAMPLE TIME	930 AM					
PERCENT	GAS VOL.					
HYDROGEN 13	13.9					
NITROGEN 9	0.8					
OXYGEN						
CARBON MONOXIDE 17	0.7					
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	34.5					
ETHANE 33	17.6					
ETHYLENE 37	6.5					
PROPANE 41	14.8					
PROPYLENE 45	4.4					
ISOBUTANE 49	4.7					
NORMAL BUTANE 53	0.7					
TOTAL BUTENES 57	0.5					
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2					
NORMAL PENTANE 69	0.1					
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.6					
BTU/CU.FT.	1518					
SPEZIFIC GRAVITY	0.8959					
DIST. GDD LDW JAK KGB RWT	REMARKS			PREPARED BY DSprague SUBMITTED BY G. M. Wyman		

81 089 (9-80)

TABLE E-3. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE APRIL 1, 1981	
UNIT CRUDE	ADSORBER [illegible] GAS TO 11H13					
SAMPLE DATE	4-1-81	4-1-81				
SAMPLE TIME	11$^{\underline{00}}$ AM					
PERCENT	GAS VOL.					
HYDROGEN 13	13.5	14.2				
NITROGEN 9	1.1	1.1				
OXYGEN						
CARBON MONOXIDE 17	0.7	0.7				
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25	9.6					
METHANE 29	31.5	33.1				
ETHANE 33	16.0	16.9				
ETHYLENE 37	5.8	6.1				
PROPANE 41	15.6	16.3				
PROPYLENE 45	4.0	4.2				
ISOBUTANE 49		5.0				
NORMAL BUTANE 53	0.7	0.7				
TOTAL BUTENES 57	0.6	0.7				
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.2				
NORMAL PENTANE 69	0.1	0.1				
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.6	0.7				
BTU / CU FT	~~1370~~	1537				
SPECIFIC GRAVITY	0.8855	0.9117				
DIST GDD KUB JAK RLOT	REMARKS			PREPARED BY D Sprague SUBMITTED BY		

81 089 (9-80)

GAS ANALYSIS REPORT TABLE E-3. (CONTINUED)

LABORATORY GAS LAB
OPERATOR D. SPRAGUE
DATE APRIL 2, 1981

UNIT CRUDE ADSORBER	~~FUEL~~ GAS TO 11H13					
SAMPLE DATE	4-281	4-2-81				
SAMPLE TIME	9$^{\underline{00}}$ AM					
PERCENT	GAS VOL.					
HYDROGEN 13	12.6	14.3				
NITROGEN 9	0.7	0.8				
OXYGEN						
CARBON MONOXIDE 17	0.5	0.5				
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25	12.8					
METHANE 29	29.7	31.5				
ETHANE 33	15.6	16.5				
ETHYLENE 37	5.1	5.4				
PROPANE 41	17.5	18.4				
PROPYLENE 45	3.2	3.4				
ISOBUTANE 49		6.7				
NORMAL BUTANE 53	1.0	1.1				
TOTAL BUTENES 57	0.5	0.6				
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.2				
NORMAL PENTANE 69	0.1	0.1				
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.5	0.5				
BTU / CU. FT.	~~1378~~	1593				
SPECIFIC GRAVITY	0.9130	0.9422				

DIST. GDD P&I
JAK
RWT KUB

REMARKS:

PREPARED BY D Sprague
SUBMITTED BY G. G. Wiseman

81 089 (9-80)

GAS ANALYSIS REPORT

TABLE E-3. (CONTINUED)

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE APRIL 3, 1981	
UNIT CRUDE ADSORBER	GAS TO 11H13					
SAMPLE DATE	4-3-81	4-3-81				
SAMPLE TIME	8³⁰ AM					
PERCENT	GAS VOL.					
HYDROGEN 13	13.2	17.3				
NITROGEN 9	1.0	1.3				
OXYGEN						
CARBON MONOXIDE 17	0.6	0.8				
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25	9.7					
METHANE 29	32.2	39.4				
ETHANE 33	15.8	1.9	2,			
ETHYLENE 37	5.9	7.2				
PROPANE 41	15.2	18.5				
PROPYLENE 45	3.9	4.7				
ISOBUTANE 49		5.8				
NORMAL BUTANE 53	0.8	1.0				
TOTAL BUTENES 57	0.8	0.9				
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.3				
NORMAL PENTANE 69	0.1	0.1				
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.6	0.8				
Btu/cu ft		1482				
Spec Grav.		.8791				
DIST GDD (2) LDW JAK PHI RWT KVB	REMARKS			PREPARED BY	D Sprague	
				SUBMITTED BY	A. G. Wyman	

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GAS ANALYSIS REPORT TABLE E-3. (CONTINUED)

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE APRIL 6, 1981	
UNIT CRUDE ABSORBER	GAS TO 11413					
SAMPLE DATE	4-6-81					
SAMPLE TIME	8$^{\underline{30}}$ AM					
PERCENT	GAS VOL.					
HYDROGEN 13	10.5					
NITROGEN 9	1.1					
OXYGEN						
CARBON MONOXIDE 17	0.6					
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	27.6					
ETHANE 33	16.1					
HYLENE 37	5.1					
PROPANE 41	26.3					
PROPYLENE 45	3.0					
ISOBUTANE 49	7.9					
NORMAL BUTANE 53	0.8					
TOTAL BUTENES 57	0.5					
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.1					
NORMAL PENTANE 69	0.1					
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.3					
Btu/ft^3	1733					
Spec. Gr.	1.0367					

T
GDD(2) LDW
JAK P&I
RWT KVB

REMARKS

PREPARED BY DSprague

SUBMITTED BY

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TABLE E-3. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE. APRIL 7, 1981	
UNIT CRUDE ADSORBER	GAS TO 11H13	FUEL GAS TO 11H13				
SAMPLE DATE	4-7-81	4-8-81				
SAMPLE TIME	8^{30} AM	8^{30} AM				
PERCENT	GAS VOL.	GAS VOL				
HYDROGEN 13	14.7	13.9				
NITROGEN 9	1.3	1.1				
OXYGEN						
CARBON MONOXIDE 17	0.8	0.7				
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	36.4	34.6				
ETHANE 33	17.4	18.3				
ETHYLENE C_2H_4 37	6.6	6.4				
PROPANE C_3H_8 41	13.9	15.5				
PROPYLENE C_3H_6 45	3.6	4.4				
ISOBUTANE 49	3.3	3.5				
NORMAL BUTANE 53	0.6	0.4				
TOTAL BUTENES 57	0.7	0.4				
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.1				
NORMAL PENTANE 69	0.1	0.1				
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.4	0.5				
BTU/CU. FT.	1444	1488				
SPEZIFIC GRAVITY	0.8539	.8796				
DIST. GDD(2) LDW(2) JAK ~~PAI~~ RWT KVB	REMARKS			PREPARED BY D Sprague SUBMITTED BY		

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TABLE E-3. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB

OPERATOR D. SPRAGUE

DATE APRIL 8, 1981

UNIT CRUDE ADSORBER	~~[illegible]~~ GAS TO 11H13					
SAMPLE DATE	4-8-81					
SAMPLE TIME	8^{30} AM					
PERCENT	GAS VOL.					
HYDROGEN 13	13.9					
NITROGEN 9	1.1					
OXYGEN						
CARBON MONOXIDE 17	0.7					
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	34.6					
ETHANE 33	18.3					
ETHYLENE 37	6.4					
PROPANE 41	15.5					
PROPYLENE 45	4.4					
ISOBUTANE 49	3.5					
NORMAL BUTANE 53	0.4					
TOTAL BUTENES 57	0.4					
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.1					
NORMAL PENTANE 69	0.1					
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.5					
BTU/CU. FT.	1488					
SPEZIFIC GRAVITY	0.8796					

DIST 6DD(2) LDW JAK KUB RWT

REMARKS

PREPARED BY D Sprague

SUBMITTED BY

81 089 (9-80)

TABLE E-3. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB

OPERATOR D. SPRAGUE

DATE APRIL 22, 1981

UNIT CRUDE ADSORBER	GAS TO 11H13	FUEL GAS TO 11H13	FUEL GAS TO 11H13			
SAMPLE DATE	4-20-81	4-21-81	4-22-81			
SAMPLE TIME	8^{30} AM	–	–			
PERCENT	GAS VOL.	–	–			
HYDROGEN 13	15.1	13.2	11.9			
NITROGEN 9	0.8	0.6	1.0			
OXYGEN						
CARBON MONOXIDE 17	0.5	0.4	0.5			
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	31.8	26.6	28.2			
ETHANE 33	16.7	15.4	15.4			
ETHYLENE 37	5.7	4.4	4.6			
PROPANE 41	20.1	23.1	22.3			
PROPYLENE 45	3.6	3.2	3.4			
ISOBUTANE 49	4.0	10.2	10.1			
NORMAL BUTANE 53	0.5	1.6	1.5			
TOTAL BUTENES 57	0.6	0.6	0.5			
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.1	0.2			
NORMAL PENTANE 69	0.1	0.1				
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.3	0.5	0.4			
BTU / CU. FT.	1541	1744	1731			
SPECIFIC GRAVITY	0.9065	1.0364	1.0327			

DIST GDD(G) LDW JAK PAI RWT (KUB)

REMARKS

PREPARED BY DSprague

SUBMITTED BY

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TABLE E-3. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE APRIL 23, 1981	
UNIT CRUDE ABSORBER	GAS TO 11H13					
SAMPLE DATE	4-23-81					
SAMPLE TIME	$8^{\underline{30}}$ AM					
PERCENT	GAS VOL.					
HYDROGEN 13	9.0					
NITROGEN 9	1.1					
OXYGEN						
CARBON MONOXIDE 17	0.3					
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	23.3					
ETHANE 33	14.4					
ETHYLENE 37	3.6					
PROPANE 41	27.3					
PROPYLENE 45	2.7					
ISOBUTANE 49	14.6					
NORMAL BUTANE 53	2.7					
TOTAL BUTENES 57	0.4					
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2					
NORMAL PENTANE 69	0.1					
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.3					
BTU/CU. FT.	1924					
SPEZIFIC GRAVITY	1.1576					
DIST GDD(2) LDW JAK P&I RWT KVB	REMARKS			PREPARED BY DSprague SUBMITTED BY C. G. Wyman		

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TABLE E-4. ADSORBER GAS ANALYSES FOR 30-DAY TEST

GAS ANALYSIS REPORT

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE MAY 8, 1981	
UNIT CRUDE ADSORBER	GAS TO 11H13	–	–	–	–	
SAMPLE DATE	5-4-81	5-5-81	5-6-81	5-7-81	5-8-81	
SAMPLE TIME	8³⁰ AM	–	–	9⁰⁰ AM	8³⁰ AM	
PERCENT	GAS VOL.	–	–	–	–	
HYDROGEN 13	11.6	11.3	10.8	11.3	11.9	
NITROGEN 9	0.7	1.1	1.0	0.8	0.9	
OXYGEN						
CARBON MONOXIDE 17	0.6	0.6	0.6	0.9	0.6	
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	28.6	28.0	26.4	27.8	29.0	
ETHANE 33	16.3	16.5	16.9	16.7	16.7	
ETHYLENE 37	4.7	4.7	4.5	4.6	5.0	
PROPANE 41	23.8	23.3	25.4	24.2	22.5	
PROPYLENE 45	3.4	3.4	3.2	3.3	3.7	
ISOBUTANE 49	8.2	8.8	8.9	7.4	7.2	
NORMAL BUTANE 53	1.0	1.2	1.3	1.0	1.1	
TOTAL BUTENES 57	0.5	0.5	0.4	0.6	0.6	
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.2	0.1	0.3	0.2	
NORMAL PENTANE 69	0.1	0.1	0.1	0.1	0.1	
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.3	0.3	0.3	1.0	0.5	
BTU/CU. FT.	1708	1721	1755	1729	1683	
SPEZIFIC GRAVITY	1.0153	1.0277	1.0494	1.0349	1.0020	
DIST GDD(3) LDW JAK P&I RWT KUB	REMARKS			PREPARED BY DSprague SUBMITTED BY		

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TABLE E-4. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY: GAS LAB		OPERATOR: D. SPRAGUE			DATE: MAY 15, 1981	
UNIT: CRUDE ADSORBER	GAS TO 11H13	-	-			
SAMPLE DATE	5-11-81	5-12-81	5-13-81	5-14-81	5-15-81	
SAMPLE TIME	9⁰⁰ AM	8⁰⁰ AM	8³⁰ AM	-	-	
PERCENT	GAS VOL.	-	-	-	-	
HYDROGEN 12	12.9	13.5	13.4	12.5	12.7	
NITROGEN 8	0.8	0.8	1.1	1.1	1.0	
OXYGEN						
CARBON MONOXIDE 17	0.6	0.5	0.7	0.7	0.7	
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	29.2	30.9	31.0	30.7	31.6	
ETHANE 33	16.6	16.8	16.5	18.1	18.0	
ETHYLENE 37	5.0	5.0	5.0	5.2	5.3	
PROPANE 41	23.1	21.8	22.0	21.8	21.3	
PROPYLENE 45	3.7	3.5	4.0	3.8	3.3	
ISOBUTANE 49	6.1	5.1	4.5	4.2	4.3	
NORMAL BUTANE 53	0.7	0.6	0.4	0.5	0.5	
TOTAL BUTENES 57	0.6	0.6	0.6	0.6	0.6	
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.2	0.2	0.2	0.2	
NORMAL PENTANE 69	0.1	0.1	0.1	0.1	0.1	
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.4	0.5	0.5	0.4	0.4	
BTU / CU. FT.	1653	1607	1592	1600	1586	
SPEZIFIC GRAVITY	0.9808	0.9504	0.9459	0.9507	0.9403	
DIST.: GDD(2) LDW JAK PHI RWT KVB	REMARKS			PREPARED BY: D Sprague SUBMITTED BY:		

TABLE E-4. (CONTINUED)

GAS ANALYSIS REPORT

LABORATORY GAS LAB		OPERATOR D. SPRAGUE			DATE MAY 22, 1981	
UNIT CRUDE ABSORBER	GAS TO 11H13	—	—	—	—	
SAMPLE DATE	5-18-81	5-19-81	5-20-81	5-21-81	5-22-81	
SAMPLE TIME	8^{30} AM	—	—	9^{30} AM	8^{30} AM	
PERCENT	GAS VOL.	—	—	—	—	
HYDROGEN 13	12.5	12.3	14.3	13.0	12.0	
NITROGEN 9	1.2	1.0	0.9	0.8	0.8	
OXYGEN						
CARBON MONOXIDE 17	0.7	0.5	0.7	0.8	0.6	
CARBON DIOXIDE 21						
HYDROGEN SULFIDE 25						
METHANE 29	30.1	30.8	32.2	32.3	30.9	
ETHANE 33	17.1	17.6	18.5	18.3	17.3	
ETHYLENE 37	5.0	5.3	5.9	5.9	5.2	
PROPANE 41	22.8	22.9	18.8	19.5	22.4	
PROPYLENE 45	4.7	3.7	3.5	3.4	3.6	
ISOBUTANE 49	3.8	4.3	3.7	4.4	5.3	
NORMAL BUTANE 53	0.4	0.4	0.3	0.4	0.6	
TOTAL BUTENES 57	0.8	0.5	0.4	0.5	0.5	
1, 3-BUTADIENE 61						
ISOPENTANE 65	0.2	0.2	0.3	0.3	0.3	
NORMAL PENTANE 69	0.1	0.1	0.1	0.1		
TOTAL PENTENES 73						
TOTAL C_6 PLUS 77	0.5	0.4	0.4	0.4	0.4	
BTU/CU. FT.	1611	1607	1528	1563	1630	
SPECIFIC GRAVITY	0.9593	0.9532	0.9014	0.9238	0.9663	
DIST. GOD(2) LDN JAK P&I RWT KVB	REMARKS			PREPARED BY D Sprague SUBMITTED BY		

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